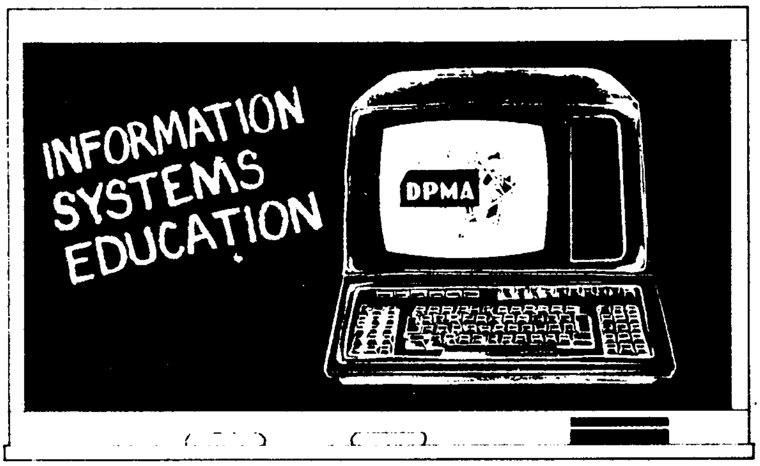
NATIONAL CONFERENCE ON

INFORMATION SYSTEMS EDUCATION



PROGRAM

DPMA Model Curriculum
Systems Analysis & Design
Program Accreditation
Industry Impact on Systems Design
Applied Software Project
Data Base Development
Professional Certification
Faculty Update
Resource Development for CIS Education
and more

TUTORIALS

Structured Systems Design and Analysis
Data Base and Data Communication
VideoGraphics in Education and Training

EXHIBITS

Software Education Corporation
The Bottom Line™
Charles E. Merrill Publishing
John Wiley and Sons
Brown Institute
Mitchell Publishing
Boeing Computer Services
and more

SPECIAL FEATURES

Vendor Reception
Birds-of-a-Feather Informal Discussion Groups
Practical Tutorials
Breakfast Seminar

CONFERENCE NOTEBOOK

Sponsored by:

Data Processing Management Association
Education Foundation
Dedicated to expanding educational opportunities for information systems professionals

MARCH 22-24, 1982
CHICAGO, ILLINOIS
McCORMICK INN

Conference managed by: **U.S. Professional Development Institute**

National Conference on

INFORMATION SYSTEMS EDUCATION

Table of Contents

National Conference on

Information Systems Education

March 22-24, 1982
Chicago, Illinois

Data Processing Management Association
Education Foundation
Dedicated to expanding educational opportunities for information systems professionals

Conference Manager:
U.S. Professional Development Institute, Inc.
12611 Davan Drive, Silver Spring, MD 20904
Telephone: (301) 622-0066

AGENDA

Registration area will be located at the Foyer - Upper Meeting Center on Monday, Tuesday and Wednesday, March 22, 23 and 24, 1982. It will provide a phone for incoming calls only. It will also provide easel and tacks for messages. Registration will be open from 8:00 AM to 5:00 PM.

TUESDAY, March 23, 1982

8:00 AM REGISTRATION & COFFEE

9:00 AM WELCOMING REMARKS AND CONFERENCE OVERVIEW — ROOM XV

by: Dr. Marvin M. Wofsey
Professor Emeritus of Management
The George Washington University

9:15 AM KEYNOTE ADDRESS: COMPUTER EDUCATION CHALLENGES FOR THE 1980s — ROOM XV

by: Dr. Thomas H. Athey
Professor, Computer Information Systems Department
California State Polytechnic University

CONCURRENT SESSIONS

INFORMATION SYSTEMS EDUCATION ON CAMPUS — ROOM VIII

10:30 AM IMPLEMENTING THE MODEL CURRICULUM — ROOM VIII

by: Dr. Daniel V. Goulet
Assoc. Prof., Dept. of Mathematics and Computer Science
University of Wisconsin, Stevens Point

AGENDA (CONTINUED)

10:30 AM IMPLEMENTING THE MODEL CURRICULUM (CONTINUED) ROOM VIII

by: Bruce M. Saulnier
Chairman, Dept. of Information Systems
Quinnipiac College

Dr. Ronald J. MacKinnon
Professor, Dept. of Mathematics and Computing Sciences
St. Francis Xavier University, Nova Scotia

SERVING BUSINESS NEEDS ROOM X

10:30 AM OPPORTUNITIES FOR INTERACTION: THE EXCHANGE OF SPECIALISTS ROOM X

by: Marvin C. Chaiken
Research and Planning Administrator
Union Mutual Life Insurance Company

Dr. Duane R. Wood
Dean, School of Business, Economics and Management
University of Southern Maine

Dr. Iza Goroff
Cochairperson, Management Systems Major
University of Wisconsin, Whitewater

12:15 PM LUNCHEON ADDRESS: THE EMERGING DISCIPLINE OF COMPUTER INFORMATION SYSTEMS ROOM V

by: Dr. David R. Adams
Coordinator, Information Systems
Northern Kentucky University

CONCURRENT SESSIONS

INFORMATION SYSTEMS EDUCATION ON CAMPUS ROOM VIII

2:00 PM ACCREDITATION AND CERTIFICATION ROOM VIII

by: Terrence J. Boyer
Vice President
Mercantile Trust Co., St. Louis

AGENDA (CONTINUED)

2:00 PM	ACCREDITATION AND CERTIFICATION (CONTINUED)	ROOM VIII

by: Dr. Roland Spaniol, CDP
Manager, Mid-West Office
R.V. Weatherford

Ronald R. Slone
Director of Accreditation
American Assembly of Collegiate School of Business

SERVING BUSINESS NEEDS — ROOM X

2:00 PM	RESOURCE DEVELOPMENT FOR COMPUTER INFORMATION SYSTEMS	ROOM X

by: Dr. Thomas Ho
Head, Dept. of Computer Technology
Purdue University

Edward A. Otting
Director, Corporate Information Systems and Services
Eli Lilly and Co.

Walter J. Hadcock
Marketing Director, Applications Services
A.O. Smith Data Systems Division

Dr. Kenneth J. Klingenstein
Acting Director of Computing Services
University of Colorado, Colorado Springs

12:00 PM- 4:00 PM	EXHIBIT	ROOM VII
4:00 PM- 6:00 PM	VENDOR RECEPTION	ROOM VII

WEDNESDAY, March 24, 1982

7:30 AM- 9:00 AM	BREAKFAST SEMINAR (Dutch Treat)	ROOM VIII

TRENDS IN DP TRAINING FOR BUSINESS AND INDUSTRY

by: Harold A. Steiner, III, President
Software Education Corporation

9:00 AM- 3:00 PM	EXHIBIT	ROOM VII

AGENDA (Continued)

CONCURRENT SESSIONS

INFORMATION SYSTEMS EDUCATION IN THE CLASSROOM — ROOM XVIII

9:00 AM TEACHING APPLICATIONS PROGRAMMING — ROOM XVIII

by: Dr. Don B. Medley
Data Processing Instructor
Moorpark College

Dr. Robert T. Grauer
Assoc. Prof., Dept. of Management Sciences
University of Miami

Roy F. Waller, CDP
Senior Member, Information Systems Development
Western Electric Co.

11:00 AM TEACHING SYSTEMS ANALYSIS & DESIGN — ROOM XVIII

by: Dr. Michael J. Powers
Chairman, Dept. of Applied Computer Science
Illinois State University

Dr. Lavette Teague
Professor of Information Systems
California State Polytechnic University

Jeffrey L. Whitten
Assistant Professor of Computer Technology
Purdue University

PROFESSIONAL DEVELOPMENT FOR BUSINESS — ROOM I

9:00 AM THE INFORMATION SYSTEMS PROFESSIONAL: WHERE WILL HE GO AND HOW WILL HE GET THERE — ROOM I

by: Paul M. Pair
Senior Educational Consultant
Control Data Corporation

Thomas J. Nardone
Supervisory Labor Economist
Bureau of Labor Statistics

11:00 AM ADVANTAGES OF IN-HOUSE TRAINING PROGRAMS — ROOM I

by: Ivan Gavrilovic
Director of Admissions and Information Systems
IBM Systems Research Institute

11:00 AM ADVANTAGES OF IN-HOUSE TRAINING PROGRAMS (CONTINUED) ROOM I

by: Dr. Terry H. Ebert
Regional Administrator
CompED Technical Corporation

Dr. Kenneth L. Villard
Internal Consultant for Organizational Development and Change
Federal Reserve Bank of Cleveland

12:15 PM LUNCHEON ADDRESS: ISSUES AND STRATEGIES FOR THE EDUCATION AND TRAINING OF SOFTWARE PROFESSIONALS ROOM VIII

by: Bartley J. Carlson
Senior Consultant
Deloitte, Haskins and Sells

CONCURRENT SESSIONS

INFORMATION SYSTEMS EDUCATION IN THE CLASSROOM ROOM V

2:00 PM AUGMENTING THE MODEL CURRICULUM: ELECTIVE COURSES ROOM V

by: Dr. John F. Schrage
Associate Professor of Management Systems and Sciences
Southern Illinois University, Edwardsville

Dr. Dorothy G. Dologite
Asst. Prof., Dept. of Statistics and Computer Info Systems
Baruch College, CUNY

Frederick Gallegos
Manager, Management Science Group
U.S. General Accounting Office

PROFESSIONAL DEVELOPMENT FOR BUSINESS ROOM VIII

2:00 PM THE APPLIED SOFTWARE DEVELOPMENT PROJECT ROOM VIII

by: Dr. Claude L. Simpson
Assoc. Professor of Computer Information Systems
Northeast Louisiana University

V. Arthur Owles
Assistant Professor, Dept. of Applied Computer Science
Illinois State University

2:00 PM THE APPLIED SOFTWARE DEVELOPMENT PROJECT (CONTINUED) ROOM VIII

by: Vince Heiker
Information Systems Manager
Boise Cascade Corporation

3:30 PM FEATURED ADDRESS: DPMA'S FUTURE COMMITMENT TO INFORMATION SYSTEMS EDUCATION ROOM V

by: Donald E. Price, CDP
President
Data Processing Management Association

BIOGRAPHIES

BIOGRAPHY OF DR. THOMAS H. ATHEY

Dr. Athey is presently professor in The Computer Information Systems Department, School of Business Administration, California State Polytechnic University, Pomona. He holds a doctorate in Business Administration from the University of Southern California.

Through his work in industry, government, and education, Dr. Athey has had extensive experience in the systems field. At Cal Poly, he received the Outstanding Teacher of the University award. He has published many articles in the leading systems journals and has a textbook A Systematic Systems Approach recently published by Prentice-Hall. Additionally, Dr. Athey is a frequent speaker at conferences of the NCC, ACM, DPMA, ASM, and has recently given several keynote addresses.

He teaches and consults in the areas of systems planning, small business computers, management information systems, and future information systems trends. Dr. Athey is a contributing editor for INTERFACE: The Computer Education Quarterly, and is Chairman of DPMA's model curriculum project for undergraduate Computer Information Systems programs nationwide.

BIOGRAPHY

BART J. CARLSON, CDE is a Senior Consultant in the Management Advisory Services Office Automation Practice at Deloitte Haskins & Sells. With over 20 years experience in computing, information systems and office automation systems, he has performed numerous consulting tasks for industry, government, and educational organizations, lectured at meetings throughout the country, and developed, marketed, and maintained several application and system software products which are installed world-wide.

Some of Mr. Carlson's recent office automation experiences at Deloitte Haskins & Sells include:

- Developed a Long Range Management Information Services Master Plan for the National 4-H Council;
- Wrote a primer on office automation for the non-technical managers/professionals of the City of Milwaukee;
- Performed an Office Automation Macro-Analysis Study for the Duke Power Company including office automation training for the Board and senior management;
- Participating as a member of the EDUCOM Task Force on Electronic Mail that is developing a national strategy for electronic mail for higher education.

Prior to joining Deloitte Haskins & Sells, he was responsible for all computing, information and office automation systems for a college of 26,000 plus students. He was responsible for several host based telecommunications networks supporting distributed mini-computers and numerous interactive terminals for administrative, instructional, and research users. He was also responsible for developing an Office Automation Pilot employing paperless office and electronic mail concepts. This project was funded entirely as a result of productivity increases on a two year full payback basis for all equipment, software and remodeling expenses and was recently awarded the NACUBO National Cost Savings Award.

He recently served as a member of the National Commission on Software Issues in the '80s and was Chairperson of the Commission's Task Force on Education/Training of Computer Software Professionals. This task force is identifying the social, economic, technical, and legal issues arising from the development, distribution, and use of computer software. He has served on the Board of Directors and as Secretary/Treasurer of CAUSE - the national professional association for administrative computing in higher education.

Contact at: Deloitte Haskins & Sells
200 East Randolph Drive
Chicago, Illinois 60601
312-861-1161

MICHEL CARTIÉR

Dr. Cartiér is professor of mediatic at the Department of Communications and Director of the Laboratoire de Telematique for the University of Quebec in Montreal.

He has worked extensively as a printer, graphic artist, character engraver, television producer and choreographer. As television producer and choreographer, his work includes productions for "Man and His World", Olympic Games in Mexico, 1968, and Montreal, 1977. He is also author of a book on Mediatics which is an electronic publishing technique involving preparation of information displays on a screen for subsequent transmission to one or more receivers.

Dr. Cartiér has done extensive research in the use of graphics in different environments. This includes special emphasis on Computer Assisted Instruction using microcomputer based systems, PLATO and Videotex.

Biography

MARVIN C. CHAIKEN is currently the Research and Planning Administrator at the Unionmutual Life Insurance Company in Portland, Maine, in its Corporate Administrative Services Division. This division is responsible for full computer and data services to the national organization of the insurance company operating under a budget of in excess of $25,000.000 for all systems programming operations and maintenance of information and its management. The division is also responsible for Office Administrative Services as well as Communications and Physical Plant Services.

Previously (1966-1974) he was Second Vice President for Data Processing operations. For 26 years prior, he was on the staff of the U.S. Veterans Administration, finally in their central office in Washington, D.C where his function was the management of the technical support for all remote data processing centers serving the Veterans Administration functions.

He has been an active administrator for the DPMA in its state chapter and currently is on the Executive Committee managing the new Computer Information Systems Curriculum. He has served as an advisor to the Maine Department of Education in bringing to the vocational guidance function a knowledge and working process incorporating data processing into the highschool curricula throughout the state. He is on the Board of the Maine Economics Society as well as the SCORE chapter of the Small Business Administration (a volunteer group). His MA is from Columbia University following a BA from Brooklyn College.

Contact at Unionmutual Life Insurance Company. P.O. Box 9548, Portland Me. 04122 (207)780-2356.

BIOGRAPHY

CAROL CHRISMAN is an Assistant Professor in the Computer Science Department at Northern Illinois University. She has taught there for a number of years teaching both graduate and undergraduate courses in a wide range of topics. Her areas of special interest include Data Base Systems, application design and development, and computer science education. Among her publications are papers on techniques for standardized application development and computer science curriculum issues. As the Computer Science Department's Director of Undergraduate Studies from 1979-1981, Carol helped organize and coordinate the advising and record keeping for over 800 undergraduate majors. She also serves as a representative to the Chicago Data Processing Education Council (CDPEC).

During 1979-1980, she was Data Base Coordinator for the Administrative Computer Center at Northern Illinois Univ. She helped develop a Student Data Base as part of the development team for a Student Information System.

Dr. Chrisman received a Ph. D. and a M. S. in Mathematics from Purdue University and a A. B. also in Mathematics from the University of Detroit.

Contact at: Computer Science Department
Northern Illinois University
DeKalb, Illinois 60115

(815) 753-0378

BIOGRAPHY

GERRY L. CHRISMAN is an Assistant Professor of Computer Science at Northern Illinois University. His principal areas of interest are data base design (especially entity-relationship models), data base applications, and software design methodology. He has taught a wide range of courses, from data base to systems analysis and design, from introductory courses in COBOL and IBM Assembler to operating systems concepts. He has also been active an an undergraduate advisor, and has supervised individual independent study projects.

In the summer of 1981, he worked as a member of a systems programming group at Bell Laboratories, Naperville, Illinois, designing and implementing the initial stages of a system for monitoring the availability of a Mass Storage System.

Previously, he taught mathematics and mathematics education at St. Xavier College (1977-78) and Northern Illinois University (1974-77). He principally taught elementary school mathematics content and methods courses for undergraduates and math education foundations and research methods for graduate students. He also supervised secondary student teachers in mathematics.

Dr. Chrisman has a PH.D. in Mathematics Education, as well as an M.S. and B.S. in Mathematics, all from Purdue University.

Contact at: Computer Science Department
Northern Illinois University
Dekalb, IL 60115

BIOGRAPHY

DOROTHY G. DOLOGITE is an Assistant Professor in the Department of Statistics and Computer Information Systems at Baruch College - City University of New York. She teaches courses in Systems Analysis and Design, On-line Systems, Business Application Programming, and Introduction to Computer Concepts. She also has developed and teaches a new course on Small Computers for Business. She has many articles about small computers that have appeared in such publications as Data Management, the Journal of Systems Management, Business Horizons, and others. Currently, she is writing a book about small computers.

Before joining the academic area, she worked in the data processing industry for twelve years. Most of that time involved work in the small computer area with hardware manufacturing and software development firms. She published numerous articles about new computer software products and hardware enhancements. She also taught management computer courses.

Dr. Dologite received a Ph.D. and M.A. from St. John's University, and a B.S. from Rider College.

Contact at: Department of Statistics and
Computer Information Systems
Baruch College - City University of New York
17 Lexington Avenue
New York, New York 10010

(212) 725-3147

BIOGRAPHY

DR. TERRY H. EBERT is the Regional Administrator of CompEd Technical Corporation, a subsidiary of Spiridellis & Associates, Inc. CompEd provides public and client-site training in various DP disciplines such as CICS, IMS, etc. In support of this effort Dr. Ebert is responsible for both group management and instructor development. He has written articles and spoken on the uniqueness of DP training and on the role of the DP trainer in reducing turnover. He is currently serving on the faculty review board of the American Institute of Banking.

Previously, he was Senior Training Specialist with CompEd, specializing in management training. He has several years experience in public education, both as a teacher and administrator.

Dr. Ebert has an Ed.D. in Training Management from Hofstra University, an M.A. in Learning Psychology from S.U.N.Y. at Binghamton, and a B.A. from Queens College.

Contact at: SPIRIDELLIS & ASSOCIATES, INC.
225 Old New Brunswick Road
Piscataway, NJ 08854

(201) 981-1114

BIOGRAPHY

FREDERICK GALLEGOS is a Supervisory Management Analyst at the United States General Accounting Office. His primary functions are to research program and agency policies, audit management operations and report to interested members of Congress. He also acts as a consultant to field audit teams where EDP problems exist. Since joining the GAO in 1972, Mr Gallegos has had several major accomplishments. He established a Management Science Group with EDP Audit skills in systems design, systems analysis, data retrieval, computer programming, statistical analysis and computer performance evaluation. He assisted in the design, development and implementation of an agency-wide data processing training program, GAO Base Level ADP Course. Over the past six years, the Management Science Group has assisted over 300 audit assignments and made major contributions to the written GAO reports of 75 assignments. He was project leader in the development of an EDP Audit and Controls course for DPMA's model curriculum in Information Systems.

Mr. Gallegos has earned an MBA Degree and a BS Degree in Data Processing from the California State Polytechnic University, Pomona. He received his Certified Information Systems Auditor in January 1979, the GAO Meritorious Service Award in October 1978, College Federal Council's Honorable Mention for Accomplishment in Self Development in May 1977, GAO Special Achievement Award in 1976 and is listed in Who's Who in Finance and Industry (1979-1981). Mr. Gallegos has authored and co-authored several books and articles relating to data processing and EDP auditing. He is a member of Cal Poly Alumni Association, EDP Auditor's Association, the Association for MBA Executives, the Society for Data Educators, and the IS/DPAA Alumni Association.

He is currently a Trustee for the EDP Auditors Foundation for EDUCATION and RESEARCH. Mr. Gallegos has also served as the Executive Vice President and Secretary/Trustee for the Foundation. Further, he has served on the Board of Directors of the EDP Auditors Association/Los Angeles Chapter. Mr.Gallegos has taught numerous graduate and undergraduate EDP courses at California State Polytechnic University, Pomona. Also, he has been responsible for the development and implementation of an M.S. program in EDP Auditing at Cal Poly as well as assisted in the establishment of the Information Systems/Data Processing Alumni Association. In 1980, he was selected by the Information Systems Department as its Outstanding Alumni. Also, he was selected OUTSTANDING ALUMNUS, for the School of Business for 1982 - CALIFORNIA STATE POLYTECHNIC UNIVERSITY POMONA, Ca.

CONTACT AT: U.S. General Accounting Office
Suite 1010, WTC
350 S. Figueroa St.
Los Angeles, Ca. 90071

ph. 213-688-3813

BIOGRAPHY

IVAN GAVRILOVIC, CDP, is the Director of Admissions and Information Systems at the IBM Systems Research Institute, where he also serves as a member of the faculty. The Institute provides graduate-level education to IBM professionals in the general areas of systems science, systems engineering, and information systems. In his capacity as Director of Admissions, Mr. Gavrilovic's responsibilities include setting admissions criteria and conducting the admissions process for the several programs that the Institute offers. In his Information Systems capacity, he is responsible for providing a broad range of computing services and resources, including research facilities, computer graphics, data base administration, curriculum support systems, administrative support systems, and systems and applications development and programming. He lectures at the Institute in the area of information systems resource management.

In the 27 years that he has spent with IBM, Mr. Gavrilovic has served in a number of staff and management assignments in education, systems design and development, financial planning, product forecasting, and information systems. Prior to joining IBM he served as chief of the methods and procedures section in the U. S. Army, 36 MRU, which was stationed in Stuttgart, West Germany.

Mr. Gavrilovic took his major in English at Columbia College, and has attended executive education programs at the Harvard Business School and at the MIT Sloan School. He is a graduate of the eleventh class of the IBM Systems Research Institute and holds the DPMA Certificate in Data Processing.

Contact at: IBM Systems Research Institute
205 East 42nd Street
New York, N.Y., 10017

(212) 983-7235

BIOGRAPHY

IZA GOROFF is currently Assistant Professor of Management at the University of Wisconsin-Whitewater and Cochairperson of the Management Computer Systems (MCS) Major, a role he has filled since the approval of the major, shortly after his arrival in Fall 1977. He is also coordinator of the MCS Cooperative Studies Program and the originator of the MCS Executive Advisory Board. He is the chairperson of the Computing Activities Committee which develops computing policy for the UW-W campus with the UW-W computer center.

Previously (1974-77) he was a senior analyst for the Controller's Divison at CNA Insurance where he was responsible for coordinating the data base administration of the company with the Controller's Division and where he developed financial information analysis systems. From 1970 to 1974 he was Director of Systems for Saxon Paint and Home Care Centers. In 1969-1970 he was Associate Director of the Computer Division of Unimark International. Prior to that he had worked in theoretical solid state physics.

Dr. Goroff has a Ph.D. in Physics from the University of Pennsylvania, an M.S. and B.S. in Physics and a B.A. in liberal studies from the University of Chicago.

Contact at: Management Department
University of Wisconsin-Whitewater
Whitewater, WI 53190
(414) 472-3182

BIOGRAPHY

DANIEL V. GOULET is an Associate Professor in the Department of Mathematics and Computer Science, and Coordinator of Instructional Computing at the University of Wisconsin-Stevens Point (UW-SP). He is presently heading a team developing a major in Computer Information Systems at UW-SP.

Previously (1976-1980), he was an Associate Professor in the Industrial Engineering Department at Auburn University, Auburn, AL; (1975-76) , a Graduate Research Associate in Industrial Engineering at the University of Houston; (1972-75) Biomathematical at the Texas Institute for Rehabilitation and Research, the Texas Medical Center, Houston, Texas; (1969-72) Captain, U.S. Army, assigned to the Applied Mathematics Division, Ballistics Research Laboratory, Aberdeen Proving Grounds, Maryland; (1967-69) , Assistant Professor of Mathematics at Gustavus Adolphus College, St. Peter, Minnesota; (1965-67) Graduate Research Associate in Mathematics, University of Minnesota, Minneapolis, Minnesota.

Dr. Goulet has a Ph.D. in Industrial Engineering from the University of Houston, M.S. in Mathematics from St. Louis University, a B.A. in Mathematics from St. John's University (Minnesota), and has done additional doctoral work in mathematics and mathematics education at the University of Minnesota.

Contact at: Mathematics and Computer Science Department
Science Building
University Wisconsin-Stevens Point
Stevens Point, WI 54481

(715)-346-2120

BIOGRAPHY

ROBERT T. GRAUER is an Associate Professor of Management Science at the University of Miami, Coral Gables, FL. He is the principle author of several books on COBOL programming, including: Structured COBOL: A Pragmatic Approach, A COBOL Book of Practice and Reference, COBOL: A Vehicle for Information Systems, and The COBOL Environment (all published by Prentice Hall).

Dr. Grauer has served as a consultant to several organizations in the area of technical training. Previous to his appointment at the University of Miami, he was on the faculty of Baruch College of CUNY, and C. W. Post.

Dr. Grauer received his M.S. and Ph.D. in Operations Research from the Polytechnic Institute of Brooklyn. He holds a B.S. in Mechanical Engineering from Rensselaer Polytechnic Institute.

Contact at: Robert Grauer
2133 Northwest 102nd Terrace
Coral Springs, FL 33065

(305) 753-0345

BIOGRAPHY

DR. STEVE GUYNES is Professor of Accounting and Information Systems at North Texas State University in Denton, Texas. He teaches courses in business computer information systems, in particular systems analysis, data base, security, and privacy. His research interests include the behavioral impact of computers, security considerations, and privacy legislation. He has had over 15 articles published nationally since 1979 on the preceeding topics. He is currently concluding a major study of computer security practices in large information systems organizations.

Dr. Guynes' previous experiences include work as a consultant (1977 - 1981) to the IRS Computer Audit Specialist Group. He is vice-president of National FSI, Inc., a major financial package software firm in Dallas, Texas. From 1970 to 1977, he was a consultant to the trust departments of many large banks working with the automation of their pension services. He was previously with Ford Motor Co. (1965 - 1967) as an information specialist in the production control department.

He holds a DBA in Qualitative Analysis from Texas Tech University, and an MBA and BBA from Texas Tech in the area of operations management.

Dr. Guynes can be contacted at:

College of Business
North Texas State University
Denton, Tx. 76203
(817) 788-2311

WALTER J. HADCOCK
Marketing Director, Applications Services

EXPERIENCE (*current)

*Directs overall sales and marketing of computer services for manufacturing, accounting, and financial applications.

Managed the Manufacturing System's product line, generalized manufacturing system installations, and management consulting services for clients throughout the United States.

Conceived, proposed, budgeted, and then led a five man-year simulation study of techniques for ordering raw material and management of inventories. Identified over $1 million in annual savings.

Reduced the number of sizes of raw material used by a major manufacturing firm by over 40%. Designed and implemented a dedicated x-ray gaging/minicomputer system for both quality control and raw material allocation use. Directed the data base/data communications group for Fortune 250 Corporation.

Critiqued major military data processing organizations and reduced government expenditures by over $1 million annually. Proposed uses for Optical Character Readers throughout the military supply system.

Developed detailed analyses of anticipated performance of phase-array radar and sonar systems. Designed and implemented a computerized drafting system to develop microwave antennas directly on printed circuit boards.

PROFESSIONAL ACTIVITIES (*current)

*Member, American Production and Inventory Control Society (APICS); Vice President, Communications and Public Relations, Milwaukee APICS Chapter
*Certified Data Processor (DPMA); Certified Practitioner (APICS)
*Founding Member, Industrial Advisory Council, Department of Computer Technology, Purdue University
*Board Member, A. O. Smith Political Action Committee
*Major, U.S. Army Reserve, assigned to the Office of the Chief of Staff for Operations, Pentagon
*Meritorious Service Medal, United States Army
GUIDE International, Project Manager, Data Base Programming Languages Requirements
*Member, Lake Shore Club and North Shore Congregational Church; Sunday School Teacher; Member, Board of Christian Education

EDUCATION (*current)

*Student, Air War College, U.S. Air Force
Graduate, U.S. Army Command and General Staff College, 1979
Master of Science, Northwestern University, Applied Mathematics and Computer Science, 1967
Graduate Study, Syracuse University, Electrical Engineering
Bachelor of Science, University of Illinois, Electrical Engineering, 1964.

BIOGRAPHY

VINCE HEIKER is Information Systems Manager for Boise Cascade's Composite Can Division, headquartered in Hazelwood, Missouri. He is responsible for new systems development; application support; data communications; voice communications; data base management; computer operations and systems software.

Mr. Heiker has over twelve years experience in various data processing positions with Boise Cascade Corp., Permaneer Corp., Mallinckrodt and Emerson Electric Company.

He is a member of MENSA, APICS and ASM. He holds the C.D.P. and is listed in "Who's-Who". He has written articles appearing in "Computerworld" "Data Management", "Datamation", "Journal of Systems Management", "Infosystems", "Administrative Management" and other publications, and he reviews books for "Data Processing Digest". He served on the 1978 ANSI Flowchart Standards Committee of ACM and on the 1981 DPMA CALPOLY data processing curriculum committee. He has been a guest speaker at various IBM, Burroughs, ACM, ASM and EDP Auditors Association functions. He provides career counseling locally for university students and nationally for MENSA members.

Mr. Heiker graduated with honors from Washington University (St. Louis, Missouri) majoring in systems analysis and programming. He received his M.B.A. from Southern Illinois University (Edwardsville, Illinois) concentrating in marketing.

BIOGRAPHY

THOMAS I. M. HO is Associate Professor and Head of the Department of Computer Technology at Purdue University. Computer Technology is an undergraduate program in computer information systems that conforms very closely to the DPMA model curriculum.

Previously (1975-1978), Dr. Ho was an Assistant Professor of Computer Science and Management at Purdue University. In that capacity, he was responsible for the Computer Science Department's option in business data processing.

Dr. Ho earned the Ph.D., M.S., and B.S. degree in Computer Science, all from Purdue University.

Contact at: Department of Computer Technology
Purdue University
SCC-C
West Lafayette, IN 47907

(317) 494-2560

BIOGRAPHY

KENNETH J. KLINGENSTEIN is Assistant Professor of Computer Science and Acting Director of Computing Services at the University of Colorado, Colorado Springs. As Director, he is responsible for both administrative and instructional data processing operations as well as all computer resource planning and budgetary processes. He is also the chief campus liaison to the statewide systems, and systems manager to a local network based on a PDP 11/70. When Professor, he teaches undergraduate and graduate courses in operating systems, algorithm design, and networking; he also directs the university's Operating Systems Laboratory.

Previously he was a professor of Mathematics and Computer Science at the University of California, Santa Barbara. He also has been a Rockefeller Fellow and Regents Junior Fellow. He has consulted for CIBAR and Pueblo County District Attorney's Office on a wide variety of Security and Performance issues.

Dr. Klingenstein has a Ph.D. in Applied Mathematics from the University of California at Berkeley, an M.A. from Berkeley, and a B.A. from Brandeis University.

Contact at: Computing Services
University of Colorado, Colorado Springs
P.O. Box 7150
Colorado Springs, CO 80933-7150

(303) 593-3318

BIOGRAPHY

DON B. MEDLEY is a Data Processing Instructor at Moorpark College in Moorpark California. He is responsible for the instructional program in data processing and the institutional research functions.

Previous experience includes assignments with aerospace companies, retail institutions, and a computer manufacturer. He has recently completed a one-year research assignment with the U.S. Department of Agriculture in Beltsville, Maryland, and is active in a number of professional associations.

Dr. Medley has a B.V.E. in Vocational Education, an M.A. in Industrial Supervision from Cal State University of Los Angeles, and an EdD in Community College Administration from B.Y.U.

Contact at: Information Systems Department
California State Polytechnic University
3801 W. Temple Avenue
Pomona, CA 91768

BIOGRAPHY

THOMAS NARDONE is a labor economist at the U.S. Department of Labor in the Division of Occupational Outlook. This Division develops projections of industrial and occupational employment for use by educational planners, career counselors, and job seekers. The information developed by the Division is presented in publications, such as the Occupational Outlook Handbook, Bureau of Labor Statistics Bulletin 2075 and Employment Trends in Computer Occupations, BLS Bulletin 2101.

Mr. Nardone has a B.A. in economics from King's College.

Contact at: U.S. Department of Labor
Bureau of Labor Statistics
Room 7216
600 E Street, N.W.
Washington, D.C. 20212
202 272-5293

BIOGRAPHY

EDWARD A. OTTING is Director, Corporate Information Systems and Services at Eli Lilly and Company, which manufactures and markets 1) human health products, 2) agricultural products, 3) animal health products, and 4) cosmetics.

As Director, Corporate Information Systems and Services, he is responsible for the worldwide information systems involving 1) delivery of data processing hardware, software and network services, 2) development of new business systems and/or new technological functions, and 3) corporate consulting in areas of decision support systems and information systems business planning.

Mr. Otting's previous assignments have included responsibilities in Industrial Relations, Pharmaceutical Market Research, Corporate Affairs and Corporate Materials Planning.

Mr. Otting has an MBA in Management Science and a B.S. in Marketing/ Economics, both from Indiana University.

BIOGRAPHY

V. ARTHUR OWLES is an Assistant Professor of Applied Computer Science at Illinois State University. Within the department, he has developed and teaches courses in Structured Analysis and Structured Design. He manages and supervises senior students in Directed Project in the development and implementation of computer information systems for university and business users. Additionally he is heavily involved in establishing and maintaining business contacts to gain input for curriculum development and to facilitate university and business interfaces. He was a member of the CIS7 team for the DPMA Model Curriculum and also contributed to the development of CIS4 and CIS5. He has presented a number of talks in Structured Analysis at conferences and meetings and has developed and conducted professional development seminars in Structured Analysis and Design for business. He has consulted with several companies in the areas of their application systems and their systems development methodology.

Prior to joining the faculty at Illinois State in 1978, he was the Manager of Marketing and Actuarial Services in the Management Information Services Division of Country Life Insurance. During his eight years there, he managed and conducted the analysis and design of several major systems supporting life, health, annuity, and group insurance business.

He holds a Masters Degree in Mathematics and has attended numerous professional development seminars.

Contact at: Applied Computer Science Department
Illinois State University
Normal, IL. 61761

(309) 436-7148   436-8338 (Department office)

8100-34th Avenue South
Mailing Address/Box 0
Minneapolis, Minnesota 55440

Paul M. Pair
Senior Education Consultant
1438 W. Broadway
Tempe, AZ 85282
602/968-8791

CONTROL DATA CORPORATION

B I O G R A P H Y

PAUL M. PAIR, EDUCATOR, LECTURER, CONSULTANT

Mr. Pair is Senior Education Consultant with Control Data Corporation. The company is one of the major manufacturers of hardware, but more recently, its major emphasis is that of providing software systems, advanced technology and educational services throughout the free world. Control Data's "trademark" in educational technology is best known by its PLATO Individualized Instruction Systems. Pair's charter with the company is that of educator, lecturer, consultant.

Pair has established a role of leadership in the Accredited Proprietary School field, having founded the Pair School of Business in 1953 and Automation Institute of Chicago in 1957, the latter was the first data processing school in the Midwest. Ten years later it was the first such institution in the nation to be accredited by the U.S. Office of Education. During 1968 it was aquired by Control Data and Pair has served the Company as a Senior Education Consultant since that time.

Pair's earlier career was in the field of public education, having served as teacher, principal, superintendent and teachers college staff. He earned his B.A. at McPherson College (Kansas) and M.A. (Education) at the University of Washington. He is a member of Phi Delta Kappa (Education) and an Honorary Member of Delta Pi Epsilon (Business Education). Pair was given the Award of Merit by McPherson College in 1962 and in 1973 was named Computer Science Man of the Year by his Data Processing Management Association chapter in Chicago. July, 1977 Control Data created the Paul M. Pair Perpetual Scholarship Award in his honor for the Institute he founded in 1957.

Mr. Pair is past president of the National Business Education Association. Currently he is Vice President of the Phoenix chapter of the Association for Systems Management and a Director of the Phoenix chapter of the Data Processing Management Association. This is his third year as a guest lecturer in the College of Business Administration, Arizona State University. He has been listed in Who's Who in America since 1947.

Pair has been a member of the board of directors of the Institute for Certification of Computer Professionals since its founding in 1973, having served as Secretary the first two years. During the ninth annual meeting of the ICCP Directors, in Scottsdale, Arizona, Pair was named an I C C P FELLOW, only the second such recognition by the Institute.

Mr. Pair is Vice President of the recently created Maricopa County (Arizona) Community College District FOUNDATION which serves the seven campuses of the System.

a service of
CONTROL DATA CORPORATION

BIOGRAPHY

MICHAEL J. POWERS is the Chairman of the Applied Computer Science Department at Illinois State University. This is an academic department emphasizing Computer Information Systems. It has implemented a major portion of the DPMA Model Curriculum. Its students do the analysis, design and implementation for both on-campus and off-campus systems. To support this activity he created a Systems Development course which incorporates structured systems analysis techniques with traditional analysis and design concepts. He was project leader for the team which developed CIS4 and CIS5 for the DPMA Model Curriculum. He has presented a number of talks and professional development seminars in the areas of structured analysis and structured design.

Prior to starting the program at Illinois State, he was Manager of Systems Development at DeKalb Ag Research. His work there concentrated on new system development, consulting to subsidiary companies, and establishing short and long range plans in the Information Services area for the parent companies and its subsidiaries.

Dr. Powers has a PhD and MA from Indiana University in Bloomington, Indiana, and a BA from Carthage College in Kenosha, Wisconsin.

Contact at: Applied Computer Science Department
Illinois State University
Normal, IL. 61761

(309) 436-8338

BIOGRAPHY

BRUCE M. SAULNIER is Associate Professor and Chairman of the Department of Information Systems at Quinnipiac College in Hamden, Connecticut. Mr. Saulnier was founding Chairman of the Department and has designed the Department's Associate, Baccalaureate, and Master's degree programs.

Previously, Mr. Saulnier served as Acting Dean of Quinnipiac's School of Business, Associate Dean of the School of Business, Assistant Professor and Chairman of the Department of Information Systems, and as an H.E.W. Fellow at the Georgia Institute of Technology.

Mr. Saulnier has an M.S. in Information and Computer Science from the Georgia Institute of Technology and a B.S. in Mathematics from Defiance College.

Contact at: Department of Information Systems
Quinnipiac College
Mt. Carmel Avenue
Hamden, Ct. 06518

(203)288-5251 ext. 343

BIOGRAPHY

John F. Schrage, Ph.D., is an Associate Professor of Management Systems and Sciences for Southern Illinois University at Edwardsville. His other major duty has been the Coordinator of the Management Information Systems Faculty. Besides his university commitment, he is currently an MIS project officer for the 102nd U.S. Army Reserve Command in Saint Louis, Missouri. His university duties mainly encompass teaching upper division and graduate courses in information systems and applications, accounting systems and auditing for computers, and advanced business programming (COBOL). He is active in the computer curriculum area for DPMA and ACM and currently is Secretary-Treasurer for the ACM SIGCSE (special interest group on computer science education). He has contributed to the DPMA model curriculum and ACM curricula in computer science, community junior colleges (operations and programming), and information systems. His publications have been mainly in curriculum but has written in MIS content areas plus present research in psychological effects on the computer professional and accounting application in/for computer systems.

He previously was associated with Purdue University (Computer Technology Department), Muskegon (Michigan) Community College, Pennsylvania State University, and the United States Government. On a continuing basis, he does independent consulting for small businesses and the major computer textbook publishers. His experiences have been in accounting, personnel, and management plus all facets of the computer field from operations to computer management.

Dr. Schrage received his Ph.D. from Michigan State University in Business Education and Administration and his M.S. and B.S. from Southern Illinois University at Edwardsville in Business and Applied Mathematics, respectively.

Contact at:

Southern Illinois University at Edwardsville
Management Systems & Sciences Department
Campus Box 106, Building II
Edwardsville, IL 62026

(618)-692-2504

JFS 2-82

BIOGRAPHY

CLAUDE L. SIMPSON, JR. is an Associate Professor of Computer Information Systems at the Northeast Louisiana University in Monroe, Louisiana.

Previously, he was Associate Professor of Computer Information Systems at the Pan American University in Edinburg, Texas. He is the author of several articles and monographs and has been teaching data processing for over ten years. He has also been in industry in the data processing field for about eleven years for a total of over 20 years data processing experience.

Dr. Simpson has a B.S. in Statistics and Computers from the Lousiana Tech University and an MBA and Ph. D. from the Georgia State University.

Contact at: College of Business

Northeast Louisiana University
Monroe, Lousiana 71209

BIOGRAPHY

LAVETTE TEAGUE is Professor of Information Systems at California State Polytechnic University, Pomona, where he teaches structured systems analysis and design, problem solving, and comparative programming languages. He is also a systems consultant, especially in the area of computer applications to building design, engineering and construction.

During 1975-1980, prior to his appointment at Cal Poly, his consulting projects included system requirements documents for the U. S. Army Corps of Engineers' Computer-Aided Engineering and Architectural Design System, the U. S. Department of Energy computer program for energy analysis in buildings, and design data bases and analyses for major medical center projects. From 1968-1974 he was Director of Computer Services for Skidmore, Owings and Merrill in Chicago, responsible for computer operations and program development in both the business and technical aspects of the firm's architectural, engineering and planning practice. From 1957-1968 he worked as an architectural designer in Birmingham, Alabama, and as an architect at the Rust Engineering Company and at Synergetics, Inc. He was the Rust participant in a study with IBM and Kimberley-Clark for a computer-controlled newsprint machine. Dr. Teague has also taught at Carnegie-Mellon University, UCLA, the University of Illinois (Chicago Circle) and MIT.

Dr. Teague has a B. Arch., M. S. C. E., and Ph. D in Civil Engineering Systems from the Massachusetts Institute of Technology. He received the 1966 Arnold W. Brunner Scholarship for research in architecture from the New York Chapter of the American Institute or Architects. He is a member of the Association from Computing Machinery, the American Institute of Architects, and Phi Eta Sigma, Scarab, Scabbard and Blade, Tau Beta Pi, Sigma Xi, and Chi Epsilon honor societies.

Contact at: School of Business Administration
California State Polytechnic University
3801 West Temple Avenue
Pomona, CA 91768

(714) 598-4238

BIOGRAPHY

DR. MIKE VANECEK is Associate Professor of Accounting and Information Systems at North Texas State University in Denton, Texas. He teaches courses in business computer information systems, EDP auditing, and accounting. His research interests include distributed systems, software and taxes, information resource management, and EDP auditing. He has had several articles published in computer information systems and accounting journals and is currently writing a textbook on distributed systems and teleprocessing. He is a member of DPMA, SMIS, AIDS, ACM, EDPAA, AAA, and IEEE. Dr. Vanecek has over fifteen years experience in the computer industry and has done consulting for both industrial and governmental organizations. He holds the P.E., C.D.P., and C.I.S.A. certifications.

Dr. Vanecek's previous experience includes computer systems consulting in industry and government as president of his own firm, M & M Vanecek, Inc. He was a systems analyst for six years at the Shell Oil Co. Information Center in Houston, Tx. While with Shell, he designed, developed, coordinated, and implemented operating system software on several projects. These projects included operating system support, array processor development, tape labeling, remote communication handlers, and so on. He also worked on classified projects as a computer programmer with the Applied Research Laboratories in Austin, Tx. He has over 20 years service with the Navy and the Naval Reserve in the submarine and intelligence programs.

He holds a Ph.D. in Accounting and Information Systems from the University of Texas at Austin, an M.B.A. from the University of Houston, and an M.E.E. and B.S.E.E. from North Carolina State University.

Dr. Vanecek can be contacted at:

College of Business
North Texas State University
Denton, Tx. 76203
(817) 788 2311

BIOGRAPHY

KENNETH L. VILLARD is the Internal Consultant for Organiza tional Development and Change with the Federal Reserve Bank of Cleveland. His duties include the introduction of technological change into user departments, resolution of user resistance and the training of data processing systems personnel in communication and behavioral skills as supplements to their technical training. He is also an external consultant for both public and private organizations, focusing primarily on productivity and turnover problems in data processing departments. In addition, he has authored two books: Beginnings in Relational Communication and Theory and Practice in Interpersonal Effectiveness.

Prior to his involvement with the Federal Reserve, he taught Organizational and Technological Change and Interpersonal Communication at Cleveland State University and Michigan State University.

He has a Ph.D. in Communication and Information Science from Michigan State University, an M.A. in Personnel Administration from Bowling Green State University, and also a B.S. from B.G.S.U.

Contact at: Federal Reserve Bank of Cleveland
P.O. Box 6387
Cleveland, Ohio 44101
(216) 579-2141

BIOGRAPHY

ROY F. WALLER, CDP, is a Senior Member, Information Systems Development, at Western Electric Company, Inc., Oklahoma City. He is currently the project leader for four Divisional Accounting Systems in the Information Systems Development organization. As the project leader, Mr. Waller is responsible for the development, implementation, and operation of four large computer systems: Data Base Mechanized Accounting Results System, Regular Mechanized Accounting Results System, Division Staff Reporting System, and the Mechanized Manufacturing Results System at the following company locations: Oklahoma City, Oklahoma; Dallas, Texas; Columbus, Ohio; Division Staff in Morristown, New Jersey; and Hawthorne, Lisle and Montgomery (all in the Chicago, Illinois area).

Prior to 1972, Mr. Waller was a project leader for Payroll and Personnel Systems and has also been a project leader in the Production and Inventory Control Systems for Western Electric.

Mr. Waller is active in the Data Processing Management Association (DPMA). He served as the chairman of the Education Committee for the Oklahoma City Chapter for 1981, and is the chairman of the Program Committee for 1982. Mr. Waller is also the Program Chairman for the DPMA Region III Spring Conference to be held in Oklahoma City on April 14-16, 1982. He served on the national committee of 80 computer specialists to develop a Computer Information System Model Curriculum for community colleges and universities in the United States. Mr. Waller is a member of the following professional societies:

1. Data Processing Management Association
2. American Institute of Industrial Engineers
3. The Society for Certified Data Processors
4. The Special Interest Group of Certified Data Processors

Mr. Waller has served or participated in the following:

1. Oklahoma City Works Technical Library Committee
2. Oklahoma City Works Data Collection Task Force
3. Junior Achievement Advisor for 2 years
4. Editor of the Oklahoma City Personal Computer Club
5. A vocational Technical Instructor for computer programming

Mr. Waller holds a B.A. degree from East Central State University of Ada, Oklahoma, and an M.B.A. degree from Oklahoma City University. He is also a holder of the Certified Data Processor title.

Contact at: Western Electric Company, Inc.
7725 West Reno
Oklahoma City, Oklahoma 73125

(405) 781-3218

BIOGRAPHY

JEFFREY L. WHITTEN is an Assistant Professor in the Department of Computer Technology at Purdue University. Computer Technology is an undergraduate program in computer information systems that conforms very closely to the DPMA model curriculum. Professor Whitten is the coordinating instructor of a sequence of systems analysis and design courses that includes CIS-4 and CIS-5 in the model curriculum.

Professor Whitten has been recognized by his students, teachers, and employers as both an innovative and effective instructor of systems development.

Previously (1976-1979), he was an instructor in the Department of Computer Science at Purdue University. In that capacity, he was responsible for information systems development courses.

Professor Whitten has an M.S. degree in Computer Science with emphasis on Management Information Systems and a B.S. degree in Industrial Management with a Business Data Processing technical option, both from Purdue University.

Contact at: Department of Computer Technology
Purdue University
SCC-C
West Lafayette, IN. 47907

(317)-494-2560

BIOGRAPHY

DR. MARVIN M. WOFSEY is Professor Emeritus of Management at the School of Government and Business Administration of The George Washington University. He has designed and taught computer-related courses at The George Washington University, The American University and the Department of Defense Computer Institute.

Currently he is consulting in the area of computer security, editing a book in the same area, and developing a conference in hospital mechanized systems. He has been connected with electric accounting machines since 1936 and computers since 1954. During this time he has filled practically every position in data processing. Dr. Wofsey was the Data Processing Director of the Bureau of Supplies and Accounts of the Navy Department and Computer Laboratory Director at The American University. He has been a consultant to some of the larger corporations in the country, such as Westinghouse, IBM, and the Chase-Manhattan Bank.

Dr. Wofsey has been in the Data Processing Management Association and its predecessor National Machine Accountants Association since 1960. He holds the CDP, and has served as General Chairman of the 1968 International Conference, member of the first CDP Advisory Board, International Director, and was awarded life membership both nationally and in the Washington, D.C. Chapter. He also served on the National Committee for Computer Programmer Training for the Association for Computing Machinery, and represented the DPMA at the Office of Education in developing suggested computer curriculums.

He has written two books and a monograph in the area of Computer Management, and edited another one. More than twenty of his articles have appeared in various national and international professional publications. He has lectured and/or taught in both North and South America, Europe, and Asia.

Dr. Wofsey received his Bachelor of Science in Economics from the New York University in 1935, his Master of Science in Statistics in 1942 and his Doctor of Philosophy in Public Administration in 1967 from The American University.

Contact at: Marvin M. Wofsey, Inc.
15311 Pine Orchard Drive
Silver Spring, Maryland 20906

(301) 598-7003

BIOGRAPHY

DUANE R. WOOD is Dean of the School of Business, Economics, and Management and Professor of Management at the University of Southern Maine. The School has 40 FTE faculty and over 1500 majors. It offers associate degrees in business, including a new business computer programming option, baccalaureate degrees in economics, business administration and accounting, and an MBA degree.

For eight years prior to this, he served at Central Michigan University as Director of the interdisciplinary M.S. in Administration Program, Director of the Central Michigan School of Banking, Assistant Dean for Graduate and External Programs in the School of Business Administration, and Professor of Management. He also has taught at the University of Wisconsin-Oshkosh and has directed the Indianapolis M.B.A. Program for Indiana University. From 1964-1969, he was employed as Project Engineer and Engineering Manager at Indiana Bell Telephone Company in the plant engineering department where he was responsible for implementing the use of computers in conducting feeder route design and economic cost studies.

Dr. Wood earned his D.B.A. in management and administrative studies from Indiana University, his M.B.A. from Butler University, and his B.S.M.E. from Rose-Hulman Institute of Technology. He also is a registered professional engineer in the State of Indiana.

Contact at: University of Southern Maine
96 Falmouth Street
Portland, Maine 04103
(207) 780-4020

BIOGRAPHY

ROBERT F. ZANT is a Professor of Information Systems at North Texas State University. He has researched and published in the areas of data base technology, corporate modeling, microcomputer systems and managerial accounting. Dr. Zant is also an active consultant and lecturer in professional development seminars. As an education consultant to the U.S. Internal Revenue Service, he has been a major contributor to the development of the training programs for computer audit specialists.

Prior to joining the faculty at North Texas State, Dr. Zant was with Clemson University where he taught information systems, management science and managerial accounting. Other professional experience includes work as a systems programmer at the University of Florida on a team that developed a time-sharing system and work with the Boeing Corporation as a scientific programmer developing simulations of Apollo missions.

Dr. Zant holds a Ph.D. in Economics and Business Administration from the University of Florida. He has a M.A. in management science and a B.A. in mathematics both also from the University of Florida.

TRACK I

INFORMATION SYSTEMS EDUCATION ON CAMPUS

°Implementing the Model Curriculum

°Accreditation and Certification

APPLYING MODEL CURRICULA TO A PARTICULAR ENVIRONMENT

Daniel V. Goulet
Associate Professor

Robert P. Morris
Assistant Professor

Bruce Staal
Associate Professor

Mathematics and Computer Science Department
University of Wisconsin-Stevens Point
Stevens Point, Wisconsin 54481

ABSTRACT

The computing profession as a whole has been concerned with the educational preparation for people entering the profession. The concerns have been manifested by curricula studies and proposals by several professional computing organizations, namely, ACM's Curriculum '78, IEEE's A Curriculum in Computer Science and Engineering, and most recently, DPMA's Model Curriculum. Each proposal specifies a set of courses and content, and a sequencing through the course lists. Some specify goals and terminal objectives for students completing the course structure. All address the curricular problem from the professional activity point of view. None addresses the problem from the educational setting point of view.

The thesis of this paper is that all curricula exist in a particular educational environment and must be tailored to that environment. A model is presented which examines the global problem--model curricula and educational environment--and a strategy is discussed on how the model can be applied to a particular university setting. Finally, a short case study is presented showing the results of the model applied to the design of the Computer Information Systems curriculum at the University of Wisconsin-Stevens Point.

INTRODUCTION.

The computing profession as a whole has been concerned with the educational preparation for people entering the profession. The concerns have been manifested by curricula studies and proposals by several professional computing organizations. They are ACM's Curriculum '78 (1), IEEE's A Curriculum in Computer Science and Engineering (2), CUPM's Report of Subpanel on Computer Science (6), and most recently, DPMA's Model Curriculum (3), and Pittsburgh Large User Group Education Committee's Model DP Curriculum (4). Each proposal specifies a set of courses and content, a sequencing through the course lists, and to some extent variations and modifications that can be used with varying sized departments. Some specify goals and terminal objectives for students completing the course structure. All, in a sense, provide a prescription for a successful curriculum from the professional activity's point of view. None addresses the curricular problem from the educational setting point of view.

The thesis of this paper is that all curricula exist in a particular educational environment and must be tailored to that environment. The prescription, though sound from the profession's point of view, may not work when the university's constraints are identified, nor service the user communities desiring to employ the program's graduates. This paper presents a model which examines the global problem -- model curricula, educational environment, and user community -- and discusses a strategy for applying the model to a particular university setting. Finally, a short case study is presented showing the results of the model applied to the design of the Computer Information Systems curriculum at the University of Wisconsin-Stevens Point.

THE MODEL.

The model presents a systematic way of looking at the pertinent issues surrounding the construction of a specific curriculum. The components provide a framework in which information collection and evaluation can be focused, and defensible decisions can be made. The model components and their relationships are diagrammed in Figure 1, and will be discussed one at a time.

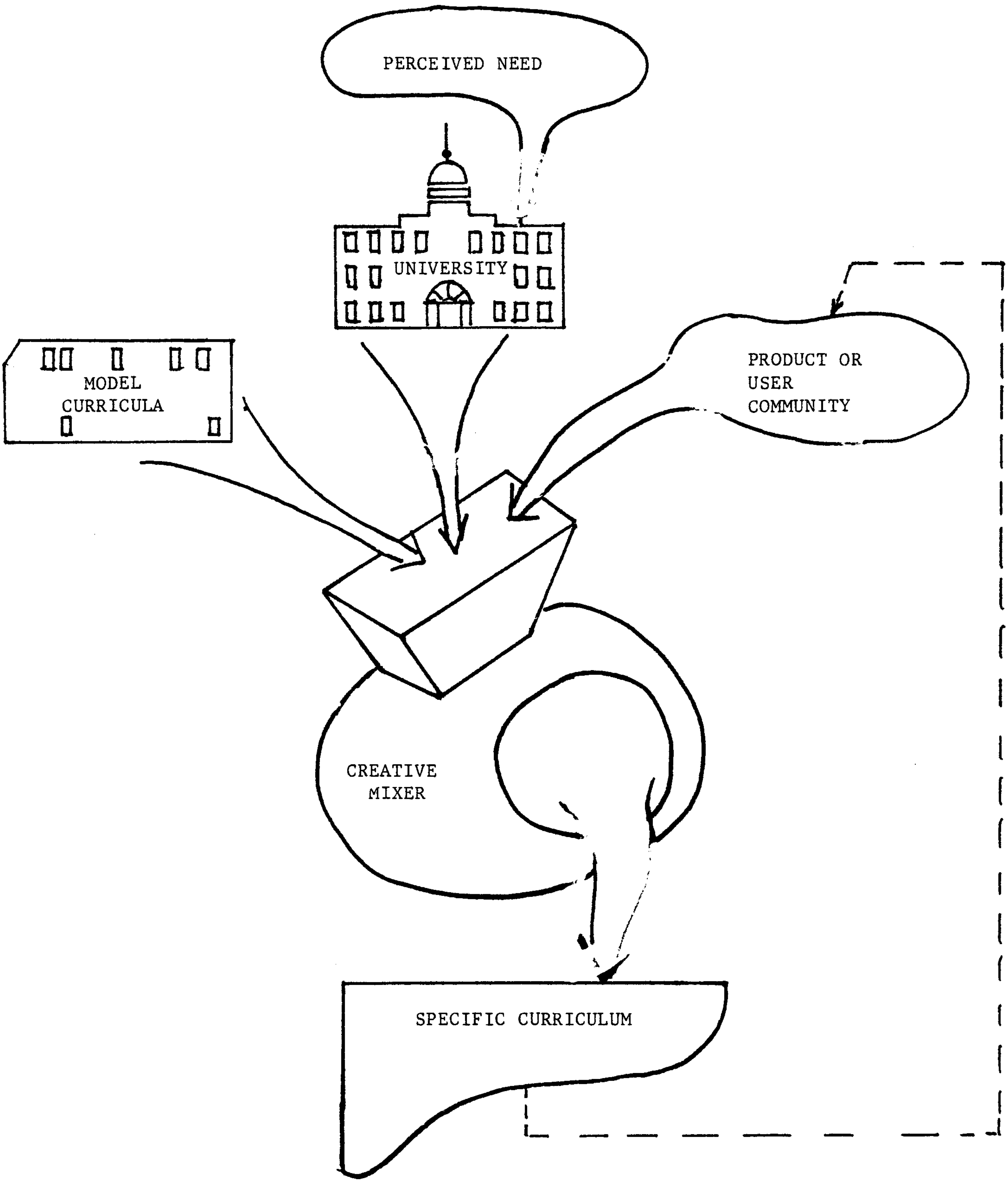


Figure 1. The Creative Mixer Model.

1. Perceived need.

The development of a curriculum at any college or university begins by first perceiving some need. The need may be as simple as looking for a program to bolster declining enrollments, or more complex like trying to service demands from students for more course work; following the lead of interested faculty members; following the directive from the upper administration to produce such a program; observing the unsatisfied demand in the user community, etc. The point is that a need is identified and the process to satisfy the need begins.

2. University.

The planning process begins with a critical and comprehensive institutional self-assessment. Computing is so pervasive that the development of a major program will have some impact on almost every unit on campus. Hence, a key assessment element is that the process extend beyond the departmental unit that will house the program. There are at least four components that must be examined. They are:

a. mission or orientation of the university
b. student body
c. faculty resources
d. computing resources

In each of the areas, a set of questions needs to be asked. Collectively, their answers will determine the educational setting for the program.

a. Mission/Orientation.

The first questions that need to be asked are, does a university mission statement exist, and if one does, does the statement have actual impact on the administration of the university and/or on the implementation of the computing program?

Next the orientation of the university must be determined. Is the school a liberal arts institution, an engineering college, a general college, etc? Is the school urban or rural?

Is there support, and to what level, for developing a computing program? What service needs does the computing program have to support? The answer to these sets of questions will determine the global parameters governing the development of the computing program.

b. Student Body.

In planning curricula, universities often overlook the student element. A rather cavaliar approach of "we know what is best" is generally taken. Students may not be able to add to curricular substance or content discussions, but they can contribute their educational and vocational expectations. These may have a dramatic effect on the program that is produced. Hence, questions like, is the student population mostly urban, rural, small town, mixed, need to be examined. Are the majority of the students first generation college students or is the student population basically one that has a history of higher education in its heritage? Are the students vocationally oriented, research oriented, graduate school oriented? What is the general intellectual level of the study body; of the students expected into the computing program? And what general expectation level do students have? Should the program attempt to satisfy these expectations, expand them, and if so, how much and in what direction? The answers to these sets of questions will identify the student population that will be serviced by the program.

c. Faculty Resources.

Curricular programs exist only if faculty are available to develop, teach, and maintain them. Faculty assessment must look both at those directly involved in the administration and delivery of the program, and those that are served by the program. The latter group will provide a sense of espirit des corps, or lack of it, for a computing program. This, in turn, can give support and direction to the program or provide considerable obstacles for its implementation.

Some of the questions for the direct support faculty are: what are the faculty interests, backgrounds, competencies? What are the faculty's views of computing? Will faculty come from retraining, new hires? The answers to this set of questions will identify the staffing needs and hiring strategies to be followed.

d. Computing Resources.

The quality of a computing curriculum is highly dependent upon hardware which supports the program. Does the university have a large mainframe and centralized system, a distributed system, departmental minis? What is the effect of micros on campus, and where do they fit into the total computing picture? What is the age of the system, and how can it be upgraded? Is there sufficient hardware funding to support a major program?

The result of a careful and extensive analysis and evaluation of the four university components listed above should provide a fairly clear picture of the education milieu in which the program is to function. The evaluation of the two remaining input elements in the model - model curricula and product or user community - will now have a local context and a framework where strengths, weaknesses, and tradeoffs can be intelligently examined.

3. Model Curricula.

The computing profession's work on identifying and articulating university computing curricula has been one of the most positive elements in constructing sound educational programs. Continuation of this work is essential for it provides direction and measures for particular curricula. However, by their nature, these model curricula reflect the profession's point of view. Each model's point of view is the single most important element in the model's statement. That point of view must be determined, and then examined for acceptance, rejection, or modification. Only then, does it make sense to examine the details contained in the model.

Thus, the remainder of this section will center on examining the perceived/stated point of view of five curricula: ACM's Curriculum '78, IEEE A Curriculum in Computer Science and Engineering, CUPM's Report of Subpanel on Computer Science, DPMA's Model Curriculum, and the Pittsburgh Large User Group Education Committee's Model DP Curriculum.

Curriculum '78. This is a computer science program. It has been designed to develop computer science as a discipline. There is a strong mathematics component. One of its major thrusts is the preparation of people who can extend or expand the field of computer science.

A Curriculum in Computer Science and Engineering. This is a computer science program which adds the engineering element to Curriculum '78. The engineering component addresses both the hardware and software. The curriculum develops computer science as a discipline from the context of this engineering component. There are strong mathematics and electrical engineering components. Graduates from the program have the preparation to extend or expand the field of computer science and engineering.

Report of Supanel on Computer Science. This is a computer science program within the context of a mathematics program or department. It follows very closely both the recommendations and coursework presented in Curriculum '78. Hence, it too is looking at computer science as a discipline.

Model Curriculum. This is a computer information systems program. The main thrust is to develop computing as a tool to solve management problems. There is a strong management component. The graduates are prepared to evaluate, manage, and use computer generated information.

Model DP Curriculum. This is a business information systems program. The main thrust is the development of computing management tools that relate directly to the use of computer generated infomation within the context of the business community needs. There is a strong management component. Graduates are expected to move into the business community with a minimal amount of additional training.

All five of the curricula basically stand apart from the educational institutions that house them. The first three address the discipline of computer science, the last two the "discipline" of computer information systems. At the risk of oversimplifying, the first three focus on the discipline as an end in itself, while the last two focus on the end product to industry and hence use the discipline as a means to an end.

4. Product or User Community.

There are three important groups which accept the vast majority of students exiting undergraduate computing program. They are: graduate schools, vendor or systems groups, and user or applications groups. What are each of these groups looking for and what questions should be asked of them?

Graduate School. The graduate school's main role whether in computer science or computer information systems is to produce people that can expand the discipline. These people may be targeted for research, education, or management, but they will still have to go through an educational program that requires them to address the concept of discipline expansion. The discipline, once again, is the end. Hence, entrants into graduate school will have to be educated in the basic components of the discipline and have a strong theoretical backing.

Vendor/Systems Groups. These groups are looking for programmers or analysts that can assist them in producing a proper functioning computer system. They are interested in software and hardware, both theoretical and actual, that will make a system work.

User/Applications Groups. These groups are interested in using the computer as a problem solving tool. Their major objective is the utility of the computer to the user. For them, problem solution is the end.

Again to risk oversimplification, the first two groups look at hardware/software as the end, while the latter group looks at hardware/software as a means to an end. The questions that need to be addressed to each group relate to the identification of both the kind and degree of training expected for entry level professionals. The answers can be used to identify proficiencies desired and success measures for individual curricula.

5. Creative Mixer.

The results from studying the educational institution, the model curricula, and the produce/user groups provide the base information for the design of a particular curriculum. The model construct for bringing all these diverse pieces of information together is the "Creative Mixer." This construct implies by its very name that there is no set algorithm for dropping out a curriculum. It is dependent on the people, place, and time in which the educational analysis takes place; that is on the cultural, environmental, and educational milieu that will receive and house the program.

Of primary concern in making the creative mixer work is the identification of a concept on which the program can be built. The program should have a thread, a design, which can be used to evaluate, accept and/or reject proposals for curricular content. The design goal is to have a cohesive program; not a hodge-podge of courses. The planning unit must accept the position that their program cannot be all things to all people. An orientation, thrust, design, mission, call it what you will, must be chosen or the program is destined to have significant problems.

The next concern for the functioning creative mixer is the product exiting the program. What does the planning unit want the outside world to see, and what level of competencies and skills are the graduates to have. These terminal competencies are not easy to identify or define, but without them the educational institution neither knows if they have reached their educational objectives, or if they say they have, how to measure success.

The third concern for the functioning creative mixer is to find the fit for the program within the total university community. No only does the questions of the major's content have to be asked, but questions of a minor program and, perhaps more important, the service role that the computing program will have to play for the rest of the university needs to be identified and integrated into the curriculum. This latter point is not addressed in any model curricula, nor can it be. It is the unique territory of the creative mixer.

The results of the work of the creative mixer is to produce a specific curriculum, satisfying specific needs, at a specific institution during a specific timeframe.

A CASE STUDY.

During the past twelve months, the Creative Mixer Model has been applied at the University of Wisconsin-Stevens Point to produce a design for a Computer Information Systems Major. A short synopsis of that process will be identified, and with the resulting curriculum presented in course title form.

1. Perceived Need.

UW-SP presently offers a 24 credit minor in computer science and no major. Since 1975, there has been a continual and large growth in student demand, approximately 40% per year. The growth has caused two problems: (a) students desire more coursework to include a major, and (b) faculty recruitment and retention for a high demand minor program is very difficult. To try to satisfy student demands and make the program more attractive to both current and future faculty, a program to construct a major was begun.

2. University.

The University self-assessment process began by examining two documents - the UW-SP catalog (7) for the mission statement and a UW Systems report (8) giving guidelines for computing programs with the System - and by interviewing faculty and administrators across the campus. The basic question posed was, "How does an expanded computing program fit into the Mathematics and Computer Science Department and into UW-SP's mission?"

Those interviewed overwhelmingly agreed that a computing major fits UW-SP's mission just as the majors in English, History, Mathematics, etc., fit. Computing should be a part of every university's academic offerings. More specifically, those interviewed expressed a clear perception that the program is a necessary support function to the University's select mission. The question that resulted was "what kind of a support role?" The answer came from a careful examination of the Mission Statement in light of the comments received and is reproduced here.

UW-SP, as one institution in the University Cluster of the University of Wisconsin System, has a core mission of "providing a first priority emphasis on teaching excellence." The select mission further identifies specific areas of focus for the campus: "communicative disorders, teacher education, home economics, paper science, and natural resources (management emphasis)." The implication of these two mission statements for the Department of Mathematics and Computer Science is clearly to define an educational support role. Hence, the department's focus should be on how that support role is interpreted and implemented.

The Select Mission and Goals contain additional statements that can be used to assist in interpretation and implementation. UW-SP should "be dedicated to implementing quality undergraduate instruction through new and innovative methods," "recognize that all fields of knowledge are interrelated," be fostering the "ability to think clearly and rationally," be developing the student's "intellectual curiosity," and be contributing to the "awareness that learning is a life-long process." Taken together, these statements demand that, as educators, we be acutely aware of the environment within which we teach and the type of students with whom we work. This requires us to use our collective creative effort to provide a program which is relevant to both.

One program orientation satisfying many of the above requirements is that of an integrated, applications oriented, problem solving activity which focuses on the end user. Let us examine each part of the above:

1. A problem solving activity focusing on the end user: Ours is an environment in which the majority of students are going to enter the job market directly upon graduation. Their basic tasks are going to demand that they solve problems. Our job is to provide the problem solving skills to attack these problems.

2. Applications oriented: In order to learn the skills of problem solving, one must do problem solving. Hence, the course structure will be applied rather than theoretical. Students will be given "hands on" experience and real life problems scaled to their level. The mathematical and computer tools will be developed as a means to solving problems.

3. Integrated: Problem solving, by its very nature, is a multidisciplinary activity. Hence our program should reflect this multidisciplinary approach by interweaving within courses from diverse disciplines the uses of many mathematical and computer tools, and by being very sensitive to attempts to compartmentalize and/or fragmentize.

The integrated, applications oriented, problem solving activity focusing on the end user requires a broadened and expanded view of the Mathematics and Computer Science Department. No longer can traditional mathematics and computer science programs be the norm. The vision must look beyond to include what is appropriate, and to discard what is not (5).

3. Model Curricula.

The model curricula that were examined together with their point of view have been identified earlier in the paper.

4. Creative Mixer.

Over a period of six months, the inputs to the Creative Mixer were discussed both formally and informally. The curriculum design philosophy accepted was: "the integrated problem solving activity, focusing on the end users." The curriculum that has resulted is an amalgamation of what the computing profession recommends: DPMA's Model Curriculum, ACM's Curriculum '78, IEEE's A Curriculum in Computer Science and Engineering and what the unique elements of UW-SP's environment require: University orientation and mission, the student body and their career objectives, the faculty and their interests, and the computing power existing on campus. The resulting program has many unique aspects, and has the potential to place the graduates from the program in highly desirable positions.

5. Specific Curriculum.

Program Objectives and Parameters:

A. Curriculum Objectives.

(1) To provide graduates with the knowledge, skills, and attitudes

(a) to function effectively as applications programmer/analysts,

(b) to have the educational background and desire for lifelong professional development.

(2) To provide understanding of the information needs and the role of information systems in business/industrial organizations.

(3) To provide the analytical and technical skills for identifying, studying, and solving information problems in business/industrial organizations.

(4) To provide the background for further study in information systems.

(5) To instill a professional attitude and seriousness of purpose about computer information systems as a career field.

B. General Teaching Concepts.

(1) Computer information systems is a skill area as well as a concept discipline. Hence, hands-on activities must be interwoven throughout the entire curricular structure.

(2) Instruction/curriculum will unfold from simplified, specific concepts to more complex and abstract principles. In particular, the course structure will emphasize programming/skill activities at the beginning with a gradual progression to a higher level of sophistication and modeling/analytical abilities toward the end of the sequence.

(3) Highly integrated methodologies need to be taught, as opposed to a potpourri of techniques. In particular, structured concepts will pervade the instructional process.

(4) Opportunities to communicate ideas and project results both orally and in written form need to be an integral part of the program.

(5) Opportunities to function individually or as part of a team need to be included.

C. Technical Considerations.

(1) The computing information field is moving rapidly toward terminal, on-line, disk-oriented, database systems.

(2) The micro-computer field will become more and more important in data processing as the costs of these machines decrease, and as their technical capabilities increase.

(3) There is an expanding use of data processing by large, medium, and small companies.

(4) Distributed data processing will soon be a part of many computer-based information systems.

(5) The need for Electronic Data Processing Auditing is becoming more prevalent.

(6) There will be a gradual merging of data processing, word processing, and data communication.

The Curricular Major.

The proposed CIS major consists of three components, a 39 credit computing major, a 21 credit collateral minor, and a 3 credit technical writing course. General degree requirements consist of 44-56 credits; however, a protion of these credits can be used to satisfy both sets of requirements. Hence, a student will have 10 to 25 free electives in their degree plan.

The computing major contains three options: (1) business option, (2) data communications option, and (3) technical support option. Each option contains a common core, an option area, and computing electives (see Figure 2).

A. The Common Core.

The common core focuses on skill activities needed throughout computing and provides the computing language facility and hardware familiarity on both large systems and small systems that will be used during the remainder of the program.

B. The Business Option.

The Business Option is designed to support and complement the existing Business Administration major with an emphasis in Management Information Systems. Business Administration focuses on the management function, while the CIS major focuses on the computer information function. The CIS Business Option requires the existing Business Administration minor as its collateral minor.

C. The Data Communications Option.

The Data Communications Option is designed to support the rapidly growing use of computers in the broad field of communications. It is built from and supports the Communication major in Fine Arts and implements the number two priority for the College of Fine Arts, that is, the expansion and linkage of the computer and the field of communications.

D. The Technical Support Option.

The Technical Support Option is designed to support a broad spectrum of disciplines that needs computing and computer information systems as problem solving tools. It is designed to support most technical disciplines as well as to provide a base for further study in computing. The program is more mathematical/quantitative than the other two orientations, and requires that its collateral minor be approved by the Coordinator of Instructional Computing.

Course Sequence.

Core

	1st sem	2nd sem
Freshmen	Pascal	FORTRAN or COBOL
Sophomore	Assembler	Large Systems
Junior	Data Structures	

	Business	Data Communications	Technical Support
Soph	Advanced COBOL	Adv FORTRAN or Adv COBOL	Advanced FORTRAN
Jr. 1st	Systems Anal	Input and Display	Input and Display
2nd	Data Base	Data Base	Operating Systems
	Input and Display	Data Communications	elective
Sr. 1st	EDP Auditing	Networks	Operations Research
	elective	elective	Simulation
2nd	DP Law	View Data	Operations Research
	elective	elective	elective

Figure 2. The Curriculum Model

SUMMARY AND CONCLUSIONS.

The thesis of this paper was that all curricula exist in a particular environment and must be tailored to that environment. A model has been presented which allows the user to do a systematic analysis and evaluation of their educational environment, and assist them in producing curricula for their cultural, environmental, and educational milieu. The process provides both a way to develop and a way to evaluate local curricula. The design methodology has assisted UW-SP in constructing its curricular model. Hopefully, it can assist others in developing theirs.

References

1. ACM Curriculum 78. Communications of ACM, March 1979. pp. 147-166.

2. A Curriculum in Computer Science and Engineering. Education Committee Report. IEEE Computer Society. November, 1976.

3. DPMA's Model Curriculum Project. Manuscript report. October 1980. Appendix A.

4. Pollack, Thomas A., Business Information Systems Curriculum. Pittsburgh Large User Group Education Committee (Manuscript). January, 1981.

5. Proposal for Authorization to Plan and Implement a New Academic Program and Description. ACIS-1, Format B. University of Wisconsin-Stevens Point. February, 1982.

6. Recommendations for a General Mathematics Sciences Program. 1981. CUPM. The Mathematical Association of America. pp. 50-70.

7. University of Wisconsin-Stevens Point. 1981-83 Catalog. pp. 4-5.

8. University of Wisconsin System Plan for Computing. 1980-1985. A Report and Recommendations of the UW System Computing Planning and Coordination Group. September, 1980. 52 pages.

QUINNIPIAC COLLEGE: A TEN YEAR CASE STUDY IN INFORMATION SYSTEMS BACCALAUREATE EDUCATION

BRUCE M. SAULNIER
CHAIRMAN, DEPARTMENT OF INFORMATION SYSTEMS
QUINNIPIAC COLLEGE

Introduction

Quinnipiac College is a private, four-year, nonsecterian institution located in Hamden, Connecticut midway between the metropolitan centers of Boston and New York City. Founded in 1929, the college has grown rapidly and now consists of three schools: Allied Health, Liberal Arts, and Business. The special mission of the college, as adopted by the Board of Trustees, is to provide the opportunity for an integrated liberal and technical education that will enable students to prepare for professional careers and to make responsible decisions in a society that increasingly demands an understanding of the humanities, the social and natural sciences, and technology. Enrollment has stabilized over the last five years and currently numbers 2300 full-time and 1500 part-time students.

Within the context of the special mission of the College, the goal of the School of Business is to prepare students for effective participation in the modern business environment, one in which both well-developed skills and a clear understanding of the needs of a humane society are urgently required. Consistent with both the special mission of the College and the goal of the School of Business, the primary objective of the Department of Information Systems is to provide an environment where students can acquire and develop technical and professional skills and attitudes to achieve two objectives: (1) acquiring the necessary skills to attain their first job in a business data processing environment and (2) establishing themselves as individuals who will make contributions to the business as a whole.

Quinnipiac College has offered the Bachelor of Science in Information Systems since the fall of 1972. Defining a "phase" as a "time frame marked by major philosophical changes in the program's educational emphasis," the dynamic nature of the discipline we call Information Systems has forced the program to undergo several changes during its evolution, changes which naturally divide the program into four distinct phases. This paper traces the evolution of the program through the four phases with respect to four central themes: (1) curriculum development, (2) faculty recruitment, (3) student body enrollment and (4) availability of appropriate computer resources.

Phase 1 1972-75

In July of 1971 Quinnipiac College hired a new Dean for its School of Business. His background was in Operations Research. Recognizing the potential for a business-oriented computer program and aware of the lack of computer expertise among his faculty, the Dean commissioned a member of the alumni association to draft a proposal for such a program. Possessing a B.S. in Accounting and an MBA from the University of Massachusetts with a concentration in Management Information Systems, the alumnus was serving as Director of Management Information Systems for the Administrative Data Systems Division of Yale University. He had taught introductory data processing courses for the college on a part-time basis for three years and his courses had been particularly well-received by the students. Student demand for such a program was high.

The resulting proposal (Fig. 1) was adopted by the faculty of the School of Business in November of 1971 and was quickly approved by the appropriate college governance bodies. The program was housed in the Accounting Department and the name of the department was changed to Accounting and Information Systems Management to reflect the two distinct programs within the department.

Faculty recruitment was begun in earnest as it was desired to formally start the program in the fall of 1972. The Search Committee quickly became aware of the fact that the presence of appropriate doctoral degrees by potential faculty candidates was a scarce comodity and compromised by hiring two individuals with backgrounds in complimentry fields: a Ph.D. in Industrial Engineering from Yale and an ABD in Information and Computer Science from Georgia Tech. Initial appointments were as Assistant Professors of Computer Science reflecting the haste of the college to commence a computer program, the "get on the bandwagon" syndrome, without adequate forthought as to the ultimate direction of the program.

The program commenced in the fall of 1972. The chairman of the department, having no computer background, schedueled classes and ordered textbooks and left all details of program implementation to the new faculty members, neither of whom had any background in implementing curricula. Initial student seatings numbered 301 in 10 class sections indicating widespread student demand without knowing exactly what would be taught. The computer was little more than a toy to the students who neither understood its basic constructs nor realized its potential uses and limitations. The students wanted to "get on the bandwagon" not realizing that the college was trying to do the same thing. In fact, the bandwagon had yet to be defined!

PHASE 1 1972-75
DEPARTMENT OF ACCOUNTING AND INFORMATION SYSTEMS MANAGEMENT
Courses in the Information Systems Management Program

	INFORMATION SYSTEMS COURSES	BUSINESS SUPPORT COURSES
FRESHMAN	IS101. Survey of Data Processing IS102. Programming Survey	AC101. Basic Accounting I AC102. Basic Accounting II
SOPHOMORE	IS201. Programming Workshop IS204. Information Systems Design	EC101. Principles of Economics I EC102. Principles of Economics II
JUNIOR	IS Elective * IS Elective *	EC254. Managerial Economics MS101. Process of Management OB102. Organizational Behavior
SENIOR	IS309. Installation Training I IS310. Installation Training II IS401. Survey of Management Information Systems	MS402. Management Decision Making
TOTAL HRS	27	24

* Students should select two electives from the following:

IS203. Data Base Concepts and Design
IS206. Design of Financial Systems
IS207. Equipment Used in Data Processing
IS304. Managing the Computer Installation

Figure 1: Phase 1

The program was dependent upon the college's administrative computer center to support its programming courses. The only computer available on campus during Phase 1 was an IBM System/3 Model 10 operating in a batch processing environment. Languages were restricted to COBOL, RPG II, and FORTRAN IV. Two keypunches were available to students who punched their programs during the day. Programs were run in batches after the close of the business day and turnaround was restricted to one per day. Students were responsible for carrying their decks of cards with them and the presence of 96-column cards made running on any other computer system nearly prohibitive.

The curriculum itself was somewhat unstructured. The support business courses were a permutation of the AACSB Common Body of Knowledge while the Information Systems courses implied two distinct options: (1) a programming option reflected by taking Data Base Concepts and Design of Financial Systems and (2) a management (operations) option reflected by taking Equipment Used in Data Processing and Managing the Computer Installation. The Programming Survey course was designed to expose students to a variety of programming languages and the Programming Workshop course was designed to give comprehensive exposure to one language, as yet to be determined. The Installation Training courses were intended to provide students with exposure to working in a computer installation for approximately 15 hours per week for academic credit, but no business installation could be reasonably expected to train students with such a sparse background.

The two full-time faculty members differed significantly in their educational approach. The individual with the industrial engineering background was a research-oriented individual with no business background. He could see no use for a "cumbersome" language such as COBOL when a more compact language such as FORTRAN was commercially available. He viewed the machine as a data cruncher for research purposes and was insensitive to the needs of the business community for report generation. Students, sensing the conflict of educational philosophies between the full-time faculty, quickly chose sides in what came to be a heated debate as to the future direction of the program.

Two-year faculty reviews were conducted in March of 1974 and it was concluded that the faculty member from Georgia Tech would remain and that the industrial engineer would be terminated at the end of the academic year. It was furthur concluded that another faculty position was warranted and approval was granted to hire two new faculty for the 1974-75 academic year. The recruitment process was again geared up since there was but six months to conduct such an effort and the faculty member from Georgia Tech was appointed to chair the search committee. The first faculty member hired had an MS in Computer Science from

Southern Illinois University coupled with additional graduate study in Computer Science at the University of Pittsburgh. The second faculty member hired had an MBA from the University of Hartford, extensive business experience, and teaching experience at the two-year state technical college level.

The 1974-75 academic year thus commenced with three full-time faculty members. There was a unified educational philosophy in that the search committee selected candidates consistent with the educational philosophy of the chairman of the committee. A major curriculum study was conducted during this year and several points were concluded:

1. There were not enough hours of information systems courses to provide an adequate academic background for the students.
2. The introductory programming courses could better serve the students if they concentrated on specific languages.
3. The installation training courses were unrealistic as requirements at this time due to the inadequacy of student backgrounds.
4. The management (operations) option was unworthy of inclusion in a four-year college curriculum.
5. The name of the program should be changed to Information Systems.
6. Sufficient electives should be made available to enable students to concentrate in a variety of areas.

Consequently, a major curriculum revision was drafted and approved by the appropriate college bodies to commence with the 1975-76 academic year.

Two other noteworthy events occurred during the 1974-75 academic year. First, a grant was secured that would enable the college to purchase additional computer resources to support its Information Systems program. This led to the purchase of a Data General Nova/2 dual-disk system with four teletypes that was in place in September of 1975. Second, it was recommended by the administration that the program had sufficient enrollments to warrant its inclusion as a separate department. Department status was to be granted commencing with the 1975-76 academic year.

Phase 2 1975-78

Phase two of the program comprised three academic years, fall 1975 thru spring 1978. The new curriculum (Fig. 2) was implemented on schedule and there was agreement among faculty, students, and potential employers that its structure was more suited to the job market as it existed in Southern New England. Three faculty members worked smoothly together and there developed a chemistry among the faculty that appeared to be contagious to the students. There existed a sense of purpose to the educational efforts and there existed a certain pride in proclaiming "I am an I.S. major!" This new found pride in identity was pertially fueled by recognition of department status and the original faculty member from Georgia Tech was named department chairman. Student enrollments were relatively constant throughout the period and numbered aproximately 375 per semester.

The Data General Nova/2 was a welcome addition to the campus computer facilities. Although severely limited in computational power, it enabled the teaching of FORTRAN and BASIC on a much faster turnaround basis and provided the vehicle for introducing both "Assembler" and "Minicomputer Concepts and Applications" into the curriculum on an elective basis. Upper level students were now able to "play" with the operating system, load programs in an octal and hexidecimal setting, and feel the full frustration of reading a core dump. Clearly, though decidedly non-utopian, the program was taking a step in the right direction.

A primary thrust of the new curriculum was to introduce COBOL and RPG into the students' educational exposure as soon as possible. It should be noted that RPG is particularly suited to southern New England with its close proximity to IBM's corporate headquarters. The course titled "Equipment Used in Data Processing" was redesigned and emerged as a more classic course in "Computer Organization" which was piggybacked with a course in "Data Base Concepts." The course in "Systems Analysis" was followed up with courses in "Teleprocessing," reflecting the trend of the industry to go on-line, and "Management Information Systems," which was now approached more from the design level that the theoretical level employed before. A course in "Advanced Business Applications," one in which students were to both design and implement a major system of programs as opposed to programs existing in isolation, was added on an elective basis. Several companies agreed to serve as installation training sites for our best students but the course was maintained only on an elective basis such that we could control the quality of the student sent to particular installations. It was concluded that an exposure to many of the business disciplines on a required basis was better than exposure to a select few and the structure of the business support courses was altered to reflect this thinking.

PHASE 2 1975-78
DEPARTMENT OF INFORMATION SYSTEMS
Courses in the Information Systems Program

	INFORMATION SYSTEMS COURSES	BUSINESS SUPPORT COURSES
FRESHMAN	IS101. Introduction to Data Processing IS201. COBOL	AC101. Basic Accounting I AC102. Basic Accounting II
SOPHOMORE	IS202. RPG II IS204. Information Systems Design IS207. Computer Organization	EC101. Principles of Economics I EC102. Principles of Economics II
JUNIOR	IS303. Data Base Concepts IS305. Introduction to Teleprocessing IS325. Management Information Systems IS Elective *	FM101. Business Finance MS101. Process of Management MK101. Marketing Systems
SENIOR	IS Elective * IS Elective * IS Elective * IS Elective *	Business Elective Business Elective
TOTAL HRS	39	27

* Students should select five electives from the following:

IS115. FORTRAN
IS125. BASIC
IS206. Financial Information Systems
IS331. Advanced Business Applications
IS409. Installation Training I
IS301. Operations Research
IS304. Managing the Computer Installation
IS315. Minicomputer Concepts
IS332. Statistical Applications
IS335. Assembler
IS410. Installation Training II

Figure 2: Phase 2

Two modifications to the faculty composition of the department were encountered during Phase 2. The faculty member with the MBA degree left the department in mid-semester (November 1975) and was replaced by another individual with an MBA from the University of Hartford possessing the CDP in January of 1976. Given the time constraints, the new faculty member had no prior teaching experience, a radical departure from traditional recruiting practice. He had an insurance background and his hiring was a conscious attempt to instill more real-world exposure to the classroom. The second modification was a direct result of the attempt to offer several electives in the Information Systems area given the lack of adequate staff to do so. A gentleman with a BS from Wharton, the CDP, and twenty years of industry experience was hired at the instructor level with the understanding that he was to complete an MBA within a given time frame. Again, a conscious attempt to instill practical data processing knowledge and background into the classroom was being made.

The 1977-78 academic year was once again a year dedicated to reexamination of the curriculum. The faculty, with a strong business background and favoring a structured, management-by-objectives approach to curriculum development, concluded that the curriculum had been developed haphazardly with little consideration for the target market (potential employers) of the finished product (students). An advisory committee consisting of several prominant local data processing executives was formed to define the proposed student outcomes and make proposals regarding the curriculum for faculty consideration. The committee proved to be invaluable and to this day functions as an active participant in nearly all department activities.

It was concluded that for the purpose of undergraduate education the Department of Information Systems should view the electronic data processing profession as being divided into systems analysis, programming, and operations. Furthur, programming may be broken down into systems and applications tasks. The curriculum of the department should concentrate upon the skills necessary within applications and systems programming, but should furthur seek to create a general interest in and appreciation for the systems process within the students. The faculty is most concerned that students are able to effectively anticipate systems problems early within their academic career. The faculty and the advisory committee believe that the electronic data processing profession can best be served on the entry level by employees who can recognize, as systems:

1. The interactions between organizational functions.
2. Approaches to the:
   a. Economics, analysis, design and implementation of their recommendations.
   b. Interests and concerns of the users of electronic data processing equipment.

The faculty and advisory council furthur believe that these systems objectives can best be effectively reached by concentrating upon creating an environment where students can actively participate in understanding:

1. The History of Data Processing
2. Techniques of:
   A. Documenting on a Detail Level
      (1) Program Specifications
      (2) Flowcharting
      (3) Decision Tables
      (4) Etc.
   B. Programming in:
      (1) COBOL
      (2) RPG II, BASIC, FORTRAN
3. Concepts for:
   A. Interviewing Users
   B. Problem Definition and Solution
      (1) Systems Approaches
      (2) Logical (Structured) Approaches
   C. Systems Flowcharting
4. The Rational for:
   A. Justifying Data Processing Budgets
   B. Selection of Hardware Configurations
   C. Developing Secure Systems without Violating Personnel Rights
5. The Need for Effective Oral and Written Communication

The faculty concluded that they can most effectively serve both the students and the data processing community by requiring students to experience accepted approaches to the above five areas through both application and practice. Therefore, instructional strategies have come to focus upon a combination of technical, practical, and professional understandings which will develop students who are effective and comfortable in a problem solving environment utilizing the power of the electronic computer. It should be noted that the computer is treated as a part of the system created to solve business problems and never as an end in itself.

Towards these ends a new curriculum modification was proposed for implementation commencing with the fall of 1978 which became the basis for phase 3 of the program.

Phase 3 1978-81

Phase 3 of the Program in Information Systems comprised three academic years, fall 1978 thru spring 1981. The new curriculum (Fig. 3) was implemented on schedule and had the effect of restricting the broad range of Information Systems electives into a more structured setting. In particular, the following changes are noteworthy:

1. EDP Problem Solving and Logic was introduced into the program as a prerequisite for all advanced courses. The course focuses on program documentation and includes such areas as writing program specifications, developing I/O layouts, and developing the flowcharting logic of applications programs. No programs are coded in this course and the applications logic developed is intentionally language independent. The introduction of this course has (1) served to "weed out" students who either do not have the apptitude or willingness from programming courses and (2) enabled the programming courses to assume a certain level of logi- sophistication and delve more deeply into the peculiarities of each particular language.
2. Advanced Business Applications was moved from an elective to required status. All students are now required to demonstrate a proficiency in writing systems of programs as a necessary condition for obtaining a degree.
3. Installation Training was reinstituted as a requirement during the senior year. The Advanced Business Applications course now serves as a prerequisite for Installation Training, thus addressing the issue of quality control. The Installation Training sequence has become the capstone of the curriculum and all prior courses are pointed to prepare the student for this senior year sequence. Thus graduating students now not only have four years of classroom exposure, but also the equivalent of six months of experience prior to obtaining their degree.

Three significant events occurred during the fall of 1979 which impacted the program. First, enrollment jumped from 355 student seatings during the fall of 1978 to 482 student seatings during the fall of 1979, necessitating the offering of additional class sections. Second, an additional faculty member was added in the fall of 1979. Appointed at the Instructor level and possessing a BS from the University of Connecticut and over 10 years of industry experience, the hiring of this individual was once again a conscious attempt to bring the real world into the classroom. Finally, the administrative computer center converted from the IBM System/3 to a Hewlett Packard 3000/III. The

PHASE 3 1978-81
DEPARTMENT OF INFORMATION SYSTEMS
Courses in the Information Systems Program

	INFORMATION SYSTEMS COURSES	BUSINESS SUPPORT COURSES
FRESHMAN	IS101. Introduction to Data Processing IS102. EDP Problem Solving and Logic	AC101. Basic Accounting I AC102. Basic Accounting II
SOPHOMORE	IS201. COBOL IS202. RPG II IS204. Systems Design IS207. Computer Organization	EC101. Principles of Economics I EC102. Principles of Economics II
JUNIOR	IS303. Data Base Concepts IS305. Introduction to Teleprocessing IS306. Operating Systems IS331. Advanced Business Applications IS335. Assembler	FM101. Corporation Finance
SENIOR	IS409. Installation Training I IS410. Installation Training II	
TOTAL HRS	39	15

As part of their graduation requirement students have fifteen hours of open electives. They normally use these to secure a minor in a support business area. No more than six hours may be taken from the following list of Information Systems electives:

IS115. FORTRAN
IS125. BASIC
IS206. Financial Information Systems
IS301. Operations Research
IS315. Minicomputer Concepts
IS332. Statistical Applications
IS337. Privacy and Security in Computer Systems

Figure 3: Phase 3

Department of Information Systems sold the Nova/2 to "piggyback" upon the HP/3000 and established a Remote Job Entry (RJE) site to the HP/3000 employing 10 CRT's, dedicated disk drives, and a line printer. This represented a significant advance for the program bacause on-campus computer facilities could finally be characterized as "state-of-the-art."

The faculty, now five in number and possessing state-of-the-art equipment, were more concerned than ever with maximizing the students' educational exposures. Although student outcomes were steadily improving and the program was establishing a solid reputation as a leader in data processing education in New England, other colleges were now attempting to jump on the band wagon and the competition for good students was increasing. Although "EDP Problem Solving and Logic" had served to bridge the gap between "Introduction to Data Processing" and "COBOL," students were having difficulty bridging the gap between "COBOL" and "Systems Design" to effectively conquer the course requirements of "Advanced Business Applications." It was clear that what we were trying to accomplish was admirable, all but the best students were having extreme difficulty designing and implementing systems of programs. Additionally, the DPMA Education Foundation had just released the first draft of their Model Curriculum and it was thought that the combination of experience at Quinnipiac, coupled with the recommendations of the Model Curriculum, would provide a sound basis for another curriculum review. A study was undertaken and the resulting curriculum (Fig. 4) became the basis for Phase 4.

Finally, sensing the potential for increasing enrollments, the college granted authorization to hire an additional faculty member for the fall of 1981.

<u>Phase 4 1981-?</u>

Phase 4 of the program in Information Systems commenced in the fall of 1981 with five-full time faculty members. The department currently has one open requisition which it is hoping to fill as soon as possible, but the nationwide shortage of qualified faculty is being particularly felt on the small-college level. Still, it is hoped that two new faculty may be recruited to start the fall of 1982.

Department enrollments took a significant increase going from 509 full-time student seatings during the fall of 1980 to 711 full-time student seatings during the fall of 1981. This increase, coupled with the difficulty in recruitment of faculty, has placed an enormous burden on the full-time faculty. To offset this increase in enrollments the faculty of the department are currently drafting a proposal to increase entrance requirements and place quotas on future incoming freshman classes. Furthur, the faculty desire to halt the practice of rolling admissions currently employed by the college in favor of a final applications

PHASE 4 1981-?
DEPARTMENT OF INFORMATION SYSTEMS
Courses in the Information Systems Program

	INFORMATION SYSTEMS COURSES	BUSINESS SUPPORT COURSES
FRESHMAN	IS101. Introduction to Data Processing IS102. EDP Problem Solving and Logic	AC101. Basic Accounting I AC102. Basic Accounting II
SOPHOMORE	IS201. COBOL I IS202. COBOL II IS251. File Structures IS330. Systems Analysis	EC101. Principles of Economics I EC102. Principles of Economics II
JUNIOR	IS211. RPG II IS307. Computer Organization IS308. Operating Systems IS331. Systems Design IS332. Systems Implementation	FM103. Corporation Finance
SENIOR	IS401. Senior Seminar IS409. Installation Training I IS410. Installation Training II	
TOTAL HRS	42	15

As part of their graduation requirements students have twelve hours of open electives. They may choose to take the following courses as partial fulfillment of their open elective requirement:

IS221. BASIC
IS231. FORTRAN

Figure 4: Phase 4

date for the program in Information Systems. It would not be surprising to find that these proposals meet with resistance at the administrative level due to the fact that college enrollment is down some 40 students from the 1980-81 academic year. The pressure to keep overall college enrollment at a constant is governed by the fact that the college budget is heavily dependent upon tuition, thus the pressure to increase enrollments in potentially expanding programs will be contrary to the proposal currently being developed by the faculty of the department. Furthur complicating the interrelated issues of faculty recruitment and expanding enrollments is the desire of the School of Business to recruit faculty with credentials that will place all departments in the school in alignment with AACSB accreditation standards.

The program is still dependent upon the Hewlett-Packard 3000/III for its computer support. Expanding enrollments have placed enormous pressure upon the computer resources and ideally the program should have more terminals to support its course offerings. Realistically this cannot now be done for two reasons: (1) there does not currently exist sufficient physical space alloted to the department to support an increase in terminals and (2) increasing the number of computer terminals given the existing computer configuration may seriously impact on response time. Thus, it appears unlikely that the program will be able to accomodate much more expansion in student enrollments unless (1) a solution is found to the current space problem and (2) the college makes a long-term commitment to upgrade its computer configuration.

The academic program currently in effect (Fig. 4) has attempted to address the problem of insufficiently prepared students in the advanced business applications course. The following changes were made to the Phase 3 program:

1. Students are now given exposure to programming starting in the first semester of their sophomore year and continuing every semester by (1) adding a second COBOL course in the second semester of their sophomore year and (2) moving RPG to the first semester of their junior year.
2. "File Structures" was added as a second logic course to follow up "EDP Problem Solving and Logic." It has replaced the "Data Base Concepts" course and includes in its latter part an exposure to data structures and data bases. The first logic course is thus a prerequisite for the first COBOL course and the second logic course has become a prerequisite for the second COBOL course.

3. It was concluded that a separate course in Teleprocessing was unwaranted in lieu of the fact that almost all applications are now in real-time environment and that it was appropriate to teach real-time concepts throughout the curriculum. Furthur, the desire to include structured methodoligies in the design course precluded the exposure to a significant term project in the design course. Thus, three courses titled Systems Design, Teleprocessing, and Advanced Business Applications have been replaced with courses titled Systems Analysis, Systems Design, and Systems Implementation in which the faculty will focus on the project life cycle commencing with the problem definition, user requirements, and feasibility study in the analysis course, the systems proposal in the design course, and the actual implementation of the system that was analized and designed in the implementation course. It is hoped that this approach, coupled with the constant exposure to programming languages, will make the implementation course a much more meaningful experience for the students and consequently improve our finished product for industry.

Conclusions

The Quinnipiac College Program in Information Systems has been traced through the past decade with respect to four themes: (1) Curriculum Development; (2) Faculty Recruitment; (3) Student Body Enrollments; (4) Availability of Appropriate Computer Resources.

The faculty of the department feel that the educational program currently in place will provide a good finished product, yet at the same time are undertaking to furthur reexamine the curriculum in light of the following influences: (1) the move on the part of the college to institute a college-wide core program, (2) the desire to ultimately seek AACSB accreditation for the program and (3) the philosophy and curricular structure of the DPMA Model Curriculum. The faculty fully support both the educational philosophy and objectives of the Model Curriculum and feel that the existing program can brought into alignment with the model curriculum with only minor alterations. A proposal is currently in the hands of the administration to change the name of the department from Information Systems to Computer Information Systems to more accurately reflect that commitment.

The faculty of the program have been traced through each of the four phases. Faculty recruitment continues to be difficult in light of industry-wide shortages of qualified personnel, academic requirements for appointment, and current salary schedules in higher education. Faculty recruitment, however, must be accomplished in light of increasing enrollments coupled with pressures to let enrollments increase to offset declines in other programs.

Finally, the problems of administering a program where computer resources are dependent upon college administrative needs were adressed. It is apparent that any program cannot continue to grow unbounded without adequate resources, especially given the increased demands of other departments to include computer courses as part of their graduation requirements. The attitudes of all departments on the college level must change from the parochial of serving their own needs to one of mutual cooperation if the computer is to become the resource that it must for all academic programs of the college.

TRACK II

SERVING BUSINESS NEEDS

°Opportunities for Interaction: The Exchange of Specialists

°Resource Development for Computer Information Systems

The Evolution of Business Support for a Computing Major

I. Goroff, UW-Whitewater*

The business community is the end user of an university program which graduates students majoring in business computing. The interaction between that business community and the university program can be mutually supportive. The relationship develops through the several stages in the evolution of the major.

During the planning stage before the business computing major has become a reality members of the business community provide two kinds of support. First, the information processing management from these companies are generous with their counsel on the curriculum content of the proposed major and on the goals of the academic program. Second, the influence of the business community is needed to provide the political support to launch a new academic program during times of fiscal retrenchment.

Once teaching in the major has begun the information processing areas of the companies in your area become a resource to be tapped for guest lecturers, project development documentation, field trips, and case studies. Eliciting support from a broad range of companies can provide remarkable enrichment of the classroom.

At a later stage the companies in your area can participate in cooperative studies programs where students in the major simultaneously gain experience and earn academic credit. The companies may provide summer faculty internships to keep the faculty member current and in touch with the reality of systems development.

The creation of an advisory board comprised of information systems management personnel drawn from your business community is the most effective way of gaining that support. The personal and direct involvement of an advisory board member assures that there will be a continuation of that support. The monitoring of your academic program by the board guarantees the viability of that program.

*Management Department, UW-Whitewater, Whitewater, WI 53190

The Evolution of Business Support for a Computing Major

Iza Goroff, University of Wisconsin-Whitewater

In the past the business community recruited its data processing personnel from a variety of traditional academic backgrounds: mathematics, accounting, statistics, and others. Although many of these people succeeded in their new discipline, the business community began to recognize that the older academic programs were not the ideal preparation for a data processing career. And although many companies had and still have extensive data processing training programs, those programs could not compare in breadth or depth with the education provided through a college program.

The well known transience of data processing personnel was a further discouragement to in-house training. The companies with the best in-house training programs were inadvertently exporting their personnel to other companies who slighted their training in favor of higher salaries to the trained.

All of these factors combined with the general thirst of companies for data processing personnel have created a climate of support for college programs which prepare graduates for data processing careers. That support is there waiting to be tapped.

The relationship between the business community and the academic program develops through the stages of the development of that program.

1 Planning and Preparation

How a program starts may vary. A company with university ties may communicate its desires for a program. Or an university faculty might recognize a way to increase enrollment by providing a new and popular program. Or students may try to prepare for a data processing career using existing courses, creating a de facto program.

The initial contacts between university and company may be as indirect and informal as the comments passed between a company recruiter and graduating senior coming back to the faculty, or they may be as direct and formal as a controlled survey of the business community by the faculty.

In addition to creating the demand for its graduates companies have two roles to play during the planning stage. First, the companies through their information systems management provide counsel as to the curriculum content and goals of the program. The DPMA curriculum has recently become very well publicized, and, depending on the resources of the university setting, companies might suggest anything from a partial implementation to an expanded version of that curriculum. Local business needs and/or changes in technology could lead the business community to suggest some modifications to the curriculum. The participation of the business community in these decisions gives those companies a stake in the success of the program.

The second role the business community plays is through its role in the political community to provide the political support and impetus to start a new program. An isolated university has more forces which oppose the reallocation of resources than those which encourage change. The university's accountability to its community breaks down that isolation. The combination of a nucleus of university faculty and administration committed to the new program together with the support of the business community is required to begin.

2 Start of the Program

Once the program has started the relationship between the academic program and the business community shifts. There is less contact than before, since the plans and preparation with which the companies were involved are being implemented mostly without the companies' active participation.

It is here where some creativity is needed to continue to involve the business community in the major. Like an organ which degenerates through lack of use, business support can atrophy without continued involvement of the companies.

Companies are resources to be used in class. A guest lecturer drawn from business almost always has at least one outstanding lecture to give. It is not difficult to find out what the topic of that lecture might be and in which course it might be given. Systems classes require extensive examples of documentation. Companies are generous with copies of documentation.

Our DPMA student chapter uses companies heavily. There is at least one field trip per semester to a company site. One company visited has in impressive computer controlled automated warehouse. Another installation has a state-of-the-art graphics installation.

3 Maturity

This stage occurs after the graduation of the first class. Once a group of students has completed the program, there is the opportunity for new kinds of business support.

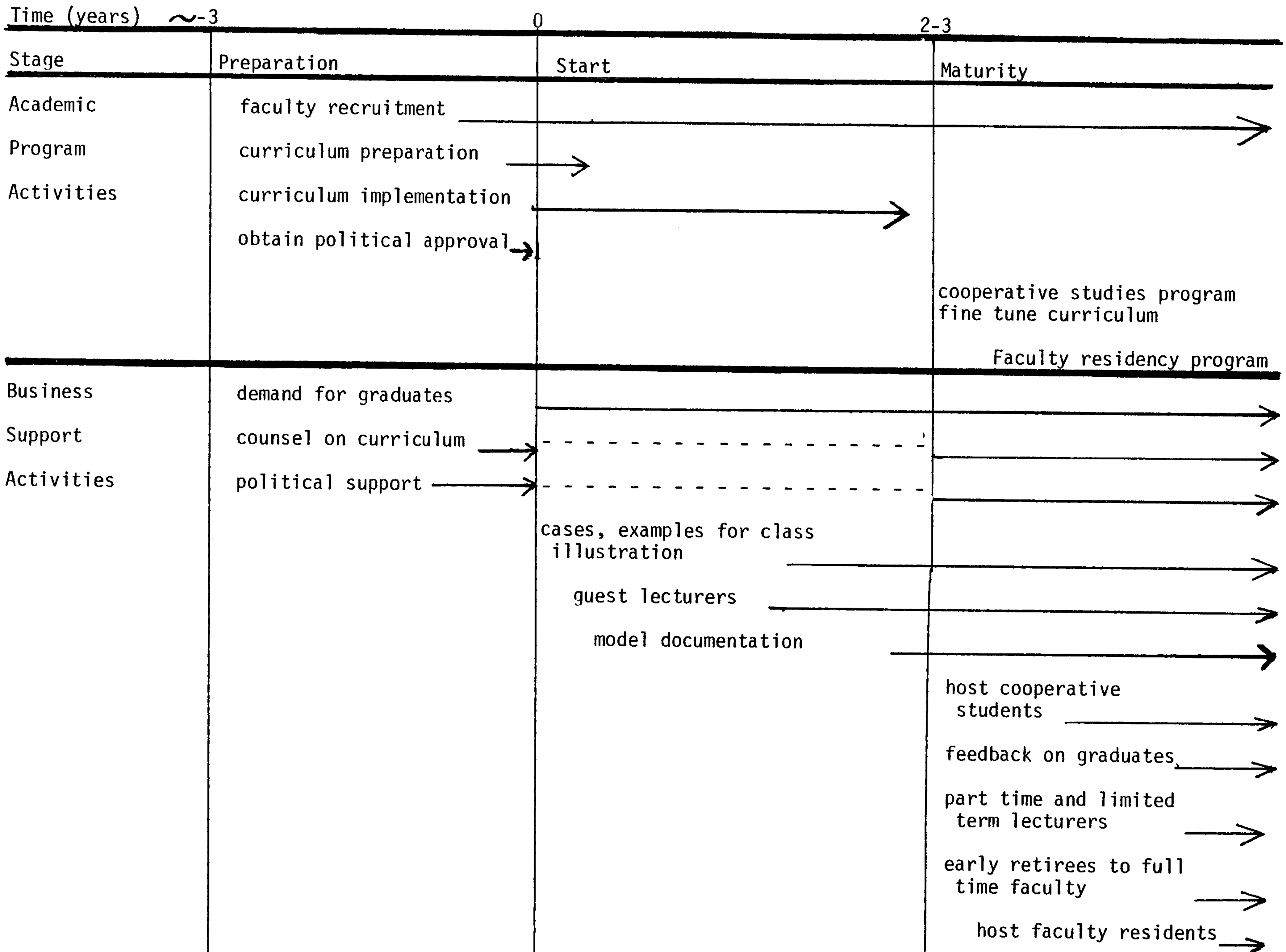
First there is feedback: How did your graduates fare in their first jobs? Was their education adequate or better? How does the business community perceive the success of your program? Constructive criticism is important. Comments from information systems managers who hired your graduates can be most useful.

Second, there is now time to enrich your program. One of the best ways is to start a cooperative studies program, common for years in engineering, but only recently implemented in data processing. Our program, now in its third year, has been considered successful by all of the students and all of the companies involved, although it has involved only about 20% of the eligible students.

Although any successful academic program requires a core of fulltime faculty (and although a percentage must hold Ph.D. degrees for accreditation), the dearth of qualified faculty means that all possible resources of faculty must be explored. High salaries for dp management has encouraged people who otherwise might have followed a teaching career to follow the business career instead. To compensate, some companies may be willing to "lend" qualified people for part-time or limited-term teaching. Occasionally, a company, to allow for continued upward mobility in its information systems department, may encourage the early retirement of some of its staff. This is a potential source of outstanding faculty.

As an academic program matures there is the danger that the faculty may lose touch with advances in the discipline. The best preventative for this is a healthy, fresh dose of experience. The business community can provide the setting for this, a summer residency program which employs faculty in the practical use of their skills. In addition to the advantages to the faculty member of sharpened skills and extra salary there are major advantages to the business community: a better faculty to produce better graduates, and the stimulation brought to the company by the "new blood" of the faculty member. The company practice is incorporated by the faculty resident into that teacher's future academic practice, as well.

The advantages of the university-business interaction are too important to be left to chance. It is best to formalize some relationships. We have created an advisory board comprised of information systems managers from sixteen companies in our service region. The board meets twice a year with agenda topics from both the faculty and board members. Almost always the faculty and board reach a consensus on each issue presented. The involvement of the board in the academic program means that each member has a stake in the success of the program, as does the faculty and the students.



Activities in the evolution of a relationship between business and an academic community program

RESOURCE DEVELOPMENT
FOR COMPUTER INFORMATION SYSTEMS EDUCATION

Dr. Thomas Ho

I. COMPUTING RESOURCES

A. HARDWARE

B. SOFTWARE

II. FACULTY RESOURCES

A. PROFESSIONAL ACTIVITIES

B. CONTINUING EDUCATION

C. PERSONAL DEVELOPMENT

COMPUTING RESOURCE ISSUES

I. ACTIVITIES

A. ACQUISITION

B. OPERATION AND MAINTENANCE

C. REPLACEMENT

II. STRATEGIES

A. SELECTION

B. FINANCING

FACULTY RESOURCE ISSUES

I. ACTIVITIES

A. RECRUITMENT

B. HUMAN RESOURCE DEVELOPMENT

C. RETENTION

II. STRATEGIES

A. SELECTION

B. PROFESSIONAL ACTIVISM

C. CONTINUING EDUCATION

D. SUPPORT

INDUSTRY RELATIONS

I. PLACEMENT

A. GRADUATES

B. SUMMER EMPLOYMENT

C. COOPERATIVE EDUCATION

II. INDUSTRY ADVISORY COMMITTEE

III. FACULTY DEVELOPMENT

A. FACULTY INTERNSHIP

B. COOPERATIVE TRAINING

IV. GIFTS

A. HARDWARE AND SOFTWARE

B. TRAINING MATERIALS

SYMBIOSIS: CAMPUS AND COMMUNITY
or
What to Do When Industry Discovers Your Town

Dr. Kenneth J. Klingenstein

One of the more interesting developments in the ongoing revolution in telecommunications and networking is the demise of the one-location corporation. Transmitting information from coast to coast is neither more difficult nor appreciably slower than transmitting across town. As a consequence, corporate expansion no longer restricts itself to a central site (which often has a depleted labor pool and a high cost of living.) Instead the decision criteria for locating a new plant may select a town with a catalyst (large military or space installations, for example) and a high quality of life (in order to attract employees.) Once a major corporation has made an initial investment in a locale, the secondary employers of consultants, subcontractors, and add-on companies usually follow. This "discovery" phenomena has occurred in many Sun Belt towns recently, including Research Triangle Park in North Carolina, Orlando, Florida, and Colorado Springs, Colorado.

In order for high-technology companies to compete successfully for employees on a nationwide level, the company must be able to provide advanced educational opportunities for its workers. Often these desires for MBA's and Masters in Computer Science or Engineering land upon a small, local, second-tier university that is ill prepared to handle either the increase in students or the demands made on faculty and equipment by advanced students. Due to an unaware administration, board of governors, or state legislature, the university may be faced with a choice of turning away students (not advised in an era of generally declining enrollments) or developing a set of creative responses that serve both university and community. In one such instance, in Colorado Springs, a university faced by a recalcitrant legislature and a rapidly growing high-technology community have joined forces to produce a quality educational environment and an expanding technical base. This paper initially examines the reasons behind the corporate effort and the academic situation. The case study is used to illustrate first the coordination of hardware/software donations to build a computing resource and then to show how the related curriculum is evolving to meet the corporate needs while enriching students and university. Finally we turn to an analysis of the potential and problems in such symbiotic relationships.

Colorado Springs, Colorado, with its high concentration of technical military installations (such as NORAD), above average quality of life and below average cost of living, was a natural for corporate expansion in the late '70s. In the last five years some 15 major high technology corporations have located R&D and production plants there. The influx of electronics firms in particular placed an inordinate strain on the educational resources of the local school, the University of Colorado at

Colorado Springs (UCCS). The Business and Engineering colleges saw an average increase of 20% per year in enrollments at all levels during this period. While the university was only tapping the surface of demand, it was already stretching its resources. Combined with the traditional lag between enrollments and resource acquisition that expanding state-financed schools experience, prospects for improvement were dim. Finally individual faculty and administrators began contacting local chief executive officers for equipment donations.

There is a variety of reasons for high-technology corporations to respond to these requests. Generally their employees are aggressively upward-mobile and want opportunities to acquire advanced degrees; in order to attract and retain employees in a nationwide market, some accredited local educational institution must competently provide the coursework. Furthermore students who use a particular brand of equipment in college tend to later become purchasers of the same brand. Learning on a given brand, these students also emerge as pre-trained job applicants upon graduation, and usually have developed a brand loyalty that steer them to that employer. There are also positive effects in the faculty of an institution receiving equipment gifts. The equipment facilitates development of hardware and software products that utilize the equipment and consultants whose inclinations are brand-oriented. Often in-house educational needs can also be met by local faculty. Conversely, advanced employees with pedagological desires can staff university courses as honoraria.

There is also an assortment of economic reasons favoring corporate donations. Usually the gifts are tax write-offs and, in the case of equipment, can be written off at their retail cost (which is about twice the internal cost.) Gifts also provide an outlet for unsellable equipment such as prototypes and blemished models. Of course, publicity of this type is never bad. And, lest we seem too mercenary, most corporate executives do have a sincere desire to generally aid education and contribute to the common good.

The university must temper its initial urge to gratefully accept donations and carefully consider several factors. Maintainence costs are skyrocketting and software support, summed over the lifetime of the gift, can easily exceed the product's original cost. Donations may sometimes be antiquated and unusable equipment or incompatible with existing resources. On the other hand, gifts may be too technologically advanced to be adequately utilized; such occasions are rather embarrassing to the institution. The fruits of a business/academic interface must, above all else, function.

In light of the possible problems for the university, the critical component of its effort is coordination. This was clearly the case at UCCS. At the onset, the configuration of the academic computer was uniformly inadequate. A PDP 11/70 running RSTS/E had one fourth of a megabyte of memory and one 67 megabyte disk supporting 14 terminals (attempting to serve the needs of 4000 computer-literate students!) Acquisition of more memory without more disks would maintain the i/o bottleneck that limited system response; increased storage without new memory had no value until more students could access the machine; and more terminals alone would seriously deteriorate the already poor system response time. Consequently no company would commit to an offer of a particular resource unless the additional resources necessary to utilize the gift were also in the works.

The negotiations in such situations are necessarily circumspect. Information on individual corporate sentiments, available equipment, and economic deadlines must be shuttled discreetly between donors. Corporate expectations must be reconciled with other university difficulties - equipment is just one (albeit significant) factor in improving an educational environment. Agreements on maintainence contracts for proposed gifts may need to be secured in advance from administrators. In some instances even remodelling or construction work to house donations must be initiated before any formal corporate commitments are made.

For UCCS, there was a fortuitous intersection of companies in the area. The local Digital Equipment Corp. plant manufactures disk drives compatible with an 11/70; they had in-house prototypes of their most recent products. United Technologies recently established a microelectronics center in the Springs and was beginning a nationwide recruiting drive. As a leading manufacturer of plug-compatible 11/70 MOS memory, they could supply the second ingredient. With these two points of the triangle of interlocking resources in place, the sister University Computer Center in Boulder extended a long term loan of terminals to guarantee the package.

The entire arrangement came together in three months, several glitches, and one panic. The effects on the system have been quite pleasant. Memory has been increased by a factor of four and storage by a factor of ten. Despite a tripling in the number of average users per hour, system response time is about four times as fast as in the previous configuration. The university capital outlay was less than $10,000.

A significant aspect of the system upgrade was the generous contributions of individual employees as well as their corporations. For example, a RSTS/E systems developer from Digital devoted several long nights to fine-tuning the operating system on the new configuration. A field service engineer supplied missing power receptacles when we ran into a nationwide

Hubble connector shortage. Disks packs mysteriously appeared. In short there was a genuine effort to help at all levels in local corporations.

The hardware/software donations described above provided the foundation for a continuing business/academic interaction on information education. It is fruitful to examine the interests of both parties in this evolving dialogue. Corporate needs for educational institutions fall roughly into two categories based upon company size. Larger companies competing in a global job market want a local school to provide advanced degrees and new employees. (Of course these companies depend heavily upon the research done at first-tier schools, but local schools can better address the aforementioned needs.) For smaller companies whose market is local, the above issues are often secondary to other needs. For example, a small business may run into a financial crisis that requires modern analytic tools found in the university. Local businesses also rely upon community publicity and spirit to compete against larger firms. And, quite frequently, the entreprenurial pride of self-made businessmen lead them to participate in academic forums.

The university's concerns in the dialogue involve balancing the increasing desire by students and industry for 'relevant' (i.e. technical) education with more traditional academic goals. In particular, the university must examine the question of advanced vocational training desired by job-oriented students versus teaching the fundamentals. An important guideline is that teaching a particular technology or system without teaching methodology means that students/employees become obsolete when the system does. The university must also convey the traditional human goals of education.

Within these constraints, there is a variety of good and common interactions: intern and summer hire programs; classroom guest lecturers and panel discussions; corporate honoraria; in-house courses,etc. The developments in Colorado Springs illustrate some interesting approaches.

In an inversion of past relationships, corporate R&D now often leads university research. Academia needs to acknowledge expertise (whatever its degree level) and utilize it. Local Digital and Hewlett-Packard R&D units have been integral to modernizing the engineering education at UCCS. DEC software support offered RSTS/E systems programming seminars for students working at the Computer Center and eventually recruited some well-trained students. Secondly, when courses require special hardware or software not found at the university, the courses can be taught at local plants having the needed facilities. For example, a VLSI course requiring a large mainframe was taught nights at the local Digital plant. While the company had to go to some lengths regarding security issues, it got the chance to have its critical employees audit the course in-house (and also recruit the top students.)

A particularly interesting educational offshoot of the donations was a series of courses designed to actually Ethernet the various computers acquired during this period. Given the rather disparate species involved (11/70 RSTS, PDP 11/40 UNIX, HP 2100 hybrid, Apples, etc.) the challenge was both unique and extremely instructive. The no-host nature of Ethernet and the variety of machines suggested a set of networking seminars, master's theses, and laboratories that slowly is integrating the campus together. Whether the systems actually have much to say to each other is unimportant; the hands-on networking experience and the sheer 'perversity' of assembling such an odd network is reason enough.

One of the more unusual approaches to 'real' education involves the College of Business and the Small Business Administration. As part of management courses, teams of students are given the accounts of failing local small businesses which need consultants. The students are permitted complete examination of financial records,etc, and use the latest on-line analytic tools to advise the businesses. Although at times it is too late to help certain businesses with severe management problems, numerous cases can be cited where the student team, advised by their business professor, have literally saved the business firm from bankruptcy. In many other cases, dramatic improvements have followed as the result of the students' consultation report--improvements in sales revenue, in management efficiency, in bookkeeping and accounting systems, and in profitability. The success of the projects has led to additional requests for consultation by various parts of the university, including student government and the snack bar.

The next few years will see an increase in corporate influx into medium-sized 'discovered' communities with second-tier academic institutions. As discussed above, there will be an unsettling period for both the university and the companies as needs and resources are examined. The situation requires a remarkable degree of coordination both within the university and between academia and business. With communication and cooperation, however, there is exceptional potential for campus and company to creatively interact for everyone's lasting benefit.

TRACK III

INFORMATION SYSTEMS EDUCATION IN THE CLASSROOM

°Teaching Applications Programming

°Teaching Systems Analysis and Design

°Augmenting the Model Curriculum: Elective Courses

THE BALANCE LINE ALGORITHM - AN APPLICATION OF STRUCTURED METHODOLOGY

PRESENTED AT THE NATIONAL CONFERENCE ON INFORMATION SYSTEMS EDUCATION, MARCH 24, 1982

ROBERT T. GRAUER, PH.D.

THE MAJOR OBJECTIVE OF THIS PAPER IS TO DEMONSTRATE THE APPLICABILITY OF THE STRUCTURED METHODOLOGY TO SEQUENTIAL FILE MAINTENANCE. THE ROLE OF THE HIERARCHY CHART IN PROGRAM DESIGN, TOP DOWN TESTING, AND PROGRAM MAINTENANCE IS EMPHASIZED. THE BALANCE LINE ALGORITHM FOR FILE MAINTENANCE IS PRESENTED THROUGH THE USE OF PSEUDOCODE.

OVERVIEW

BALANCE LINE ALGORITHM
- ACTIVE KEY
- PSEUDOCODE
- ERROR PROCESSING
- HIERARCHY CHART

TOP DOWN TESTING
- STUBS PROGRAM
- TEST DATA
- OUTPUT
- COMPLETED PROGRAM

PROGRAM MAINTENANCE
- REVISED SPECIFICATIONS
- MULTIPLE TRANSACTION FILES
- MULTIPLE TRANSACTION KEYS
- EXPANDED HIERARCHY CHART
- MODIFIED PROGRAM

BALANCE LINE ALGORITHM:

A GENERALIZED APPROACH TO SEQUENTIAL FILE MAINTENANCE

REQUIRES AT LEAST THREE FILES - AN OLD MASTER, A NEW MASTER, AND ONE OR MORE TRANSACTION FILES

THE TRANSACTION AND OLD MASTER FILES ARE IN SEQUENCE ON THE SAME KEY, WHICH IS UNIQUE FOR EVERY RECORD IN THE OLD MASTER. IT NEED NOT BE UNIQUE FOR THE TRANSACTION FILE; I.E., MULTIPLE TRANSACTIONS ARE ALLOWED FOR THE SAME MASTER RECORD.

THREE TRANSACTION TYPES ARE PERMITTED; ADDITIONS, CHANGES, AND DELETIONS; AND MAY BE PRESENTED IN ANY ORDER

THE CONCEPT OF AN ACTIVE KEY IS THE BASIS OF THE ALGORITHM

ACTIVE KEY:

- DEFINED AS THE SMALLER OF THE OLD MASTER AND TRANSACTION KEYS CURRENTLY BEING PROCESSED

```
IF TRANS-KEY < OLD-MAST-KEY
    ACTIVE-KEY = TRANS-KEY
ELSE
    ACTIVE-KEY = OLD-MAST-KEY
ENDIF
```

- AT ANY GIVEN TIME, ONLY THOSE RECORDS WHOSE KEY EQUALS THE ACTIVE KEY ARE ALLOWED TO PARTICIPATE IN THE UPDATE PROCESS.

- THE BALANCE LINE ALGORITHM IS EASILY EXTENDED TO MULTIPLE TRANSACTION FILES BY DEFINING THE ACTIVE KEY AS THE SMALLEST VALUE OF ALL KEYS CURRENTLY PROCESSED.

PSEUDOCODE

```
OPEN FILES
READ TRANSACTION-FILE, AT END MOVE HIGH-VALUES TO TRANSACTION-KEY
READ OLD-MASTER-FILE, AT END MOVE HIGH-VALUES TO OLD-MASTER-KEY
CHOOSE FIRST ACTIVE-KEY
DO WHILE ACTIVE-KEY ≠ HIGH-VALUES
    IF OLD-MASTER-KEY = ACTIVE-KEY
        MOVE OLD-MASTER-RECORD TO NEW-MASTER-RECORD
        READ OLD-MASTER-FILE, AT END MOVE HIGH-VALUES TO OLD-MASTER-KEY
    ENDIF
    DO WHILE TRANSACTION-KEY = ACTIVE-KEY
        APPLY TRANSACTION TO NEW-MASTER-RECORD
        READ TRANSACTION-FILE, AT END MOVE HIGH-VALUES TO TRANSACTION-KEY
    ENDDO
    IF NO DELETION WAS PROCESSED
        WRITE NEW MASTER-RECORD
    ENDIF
CHOOSE NEXT ACTIVE-KEY
ENDDO
CLOSE FILES
STOP RUN
```

ERROR PROCESSING:

THE TRANSACTION FILE IS ASSUMED VALID IN AND OF ITSELF BY VIRTUE OF A "STAND ALONE" EDIT

NEVERTHELESS, THERE ARE TWO KINDS OF ERRORS WHICH APPEAR ONLY IN THE ACTUAL UPDATE. THESE ARE:

DUPLICATE ADDITIONS: IN WHICH THE KEY OF A TRANSACTION CODED AS AN ADDITION ALREADY EXISTS IN THE OLD MASTER, AND

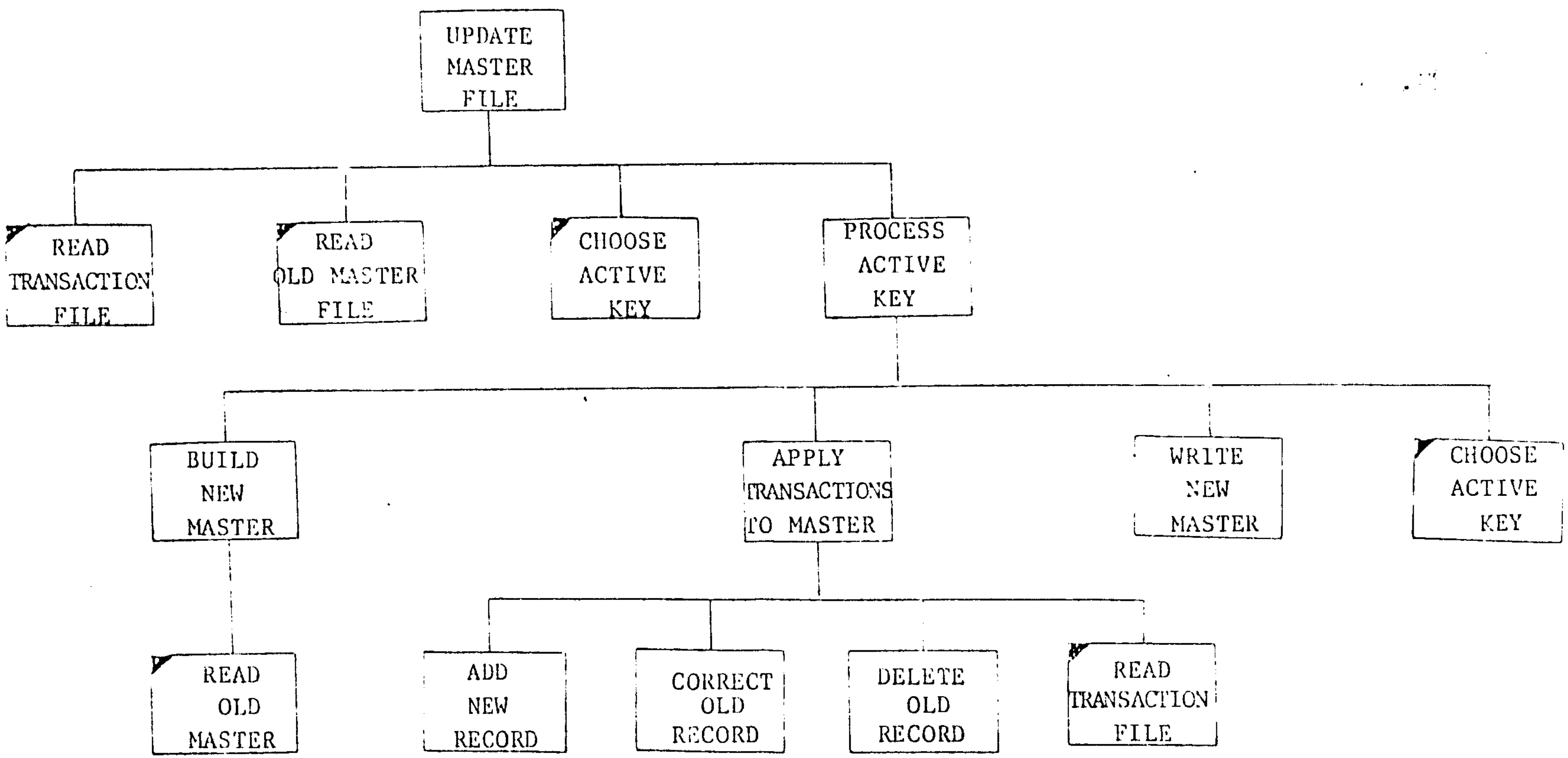
NO MATCHES: IN WHICH THE KEY OF EITHER A DELETION OR CORRECTION TRANSACTION TYPE DOES NOT EXIST IN THE OLD MASTER.

ERROR PROCESSING IS HANDLED BY ASSIGNING AN ALLOCATION STATUS TO EVERY VALUE OF THE ACTIVE KEY; I.E., THE KEY IS EITHER ALLOCATED OR NOT

EXTENDED PSEUDOCODE

```
OPEN FILES
READ TRANSACTION-FILE, AT END MOVE HIGH-VALUES TO TRANSACTION-KEY
READ OLD-MASTER-FILE, AT END MOVE HIGH-VALUES TO OLD-MASTER-KEY
CHOOSE FIRST ACTIVE-KEY
DO WHILE ACTIVE-KEY ≠ HIGH-VALUES
IF OLD-MASTER-KEY = ACTIVE-KEY
    MOVE 'YES' TO RECORD-KEY-ALLOCATED-SWITCH
    MOVE OLD-MASTER-RECORD TO NEW-MASTER-RECORD
    READ OLD-MASTER-FILE, AT END MOVE HIGH-VALUES TO OLD-MASTER-KEY
ELSE (ACTIVE-KEY IS NOT IN OLD-MASTER-FILE)
    MOVE 'NO' TO RECORD-KEY-ALLOCATED-SWITCH
ENDIF
DO WHILE TRANSACTION-KEY = ACTIVE-KEY
IF ADDITION
    IF RECORD-KEY-ALLOCATED-SWITCH = 'YES'
        WRITE 'ERROR - DUPLICATE ADD'
    ELSE (ACTIVE-KEY IS NOT IN OLD-MASTER-FILE)
        MOVE TRANSACTION-RECORD TO NEW-MASTER
        MOVE 'YES' TO RECORD-KEY-ALLOCATED-SWITCH
    ENDIF
ELSE IF CORRECTION
    IF RECORD-KEY-ALLOCATED-SWITCH = 'YES'
        PROCESS CORRECTION
    ELSE (ACTIVE-KEY IS NOT IN OLD-MASTER-FILE)
        WRITE 'ERROR - NO MATCH'
    ENDIF
ELSE IF DELETION
    IF RECORD-KEY-ALLOCATED-SWITCH = 'YES'
        MOVE 'NO' TO RECORD-KEY-ALLOCATED-SWITCH
        PROCESS DELETION
    ELSE (ACTIVE-KEY IS NOT IN OLD-MASTER-FILE)
        WRITE 'ERROR - NO MATCH'
    ENDIF
ENDIF
READ TRANSACTION-FILE, AT END MOVE HIGH-VALUES TO TRANSACTION-KEY
ENDDO
IF RECORD-KEY-ALLOCATED-SWITCH = 'YES'
    WRITE NEW-MASTER-RECORD
ENDIF
CHOOSE ACTIVE-KEY
ENDDO
CLOSE FILES
STOP RUN
```

HIERARCHY CHART



NOTES:

1. SHADED BOXES INDICATE MODULES WHICH ARE CALLED FROM MORE THAN ONE PLACE.

TOP DOWN TESTING

THE HIGHER LEVEL (AND MORE DIFFICULT) MODULES IN A HIERARCHY CHART SHOULD BE TESTED EARLIER, AND MORE FREQUENTLY, THAN THE LOWER LEVEL (OFTEN TRIVIAL) ROUTINES.

TOP DOWN TESTING SHOULD BEGIN AS SOON AS POSSIBLE, OFTEN BEFORE THE PROGRAM IS COMPLETELY FINISHED. THIS IS ACCOMPLISHED THROUGH THE USE OF PARTIALLY COMPLETED MODULES, KNOWN AS PROGRAM STUBS.

THE EARLY PHASES OF TESTING ARE MORE CONCERNED WITH THE INTERACTION BETWEEN MODULES, AND VERIFICATION THAT THE MODULES ARE CALLED IN PROPER SEQUENCE, THAN WITH THE DETAILS OF THE LOWER LEVEL ROUTINES.

CONSIDER ...

STUBS PROGRAM

```
IDENTIFICATION DIVISION.
PROGRAM-ID.    SEQSTUB.
AUTHOR.        R. GRAUER.

ENVIRONMENT DIVISION.
CONFIGURATION SECTION.
SOURCE-COMPUTER.        IBM-4341.
OBJECT-COMPUTER.        IBM-4341.

INPUT-OUTPUT SECTION.
FILE-CONTROL.
    SELECT TRANSACTION-FILE
        ASSIGN TO UT-S-TRANS.
    SELECT OLD-MASTER-FILE
        ASSIGN TO UT-S-MASTER.

DATA DIVISION.
FILE SECTION.
FD  TRANSACTION-FILE
    LABEL RECORDS ARE STANDARD
    BLOCK CONTAINS 0 RECORDS
    RECORD CONTAINS 80 CHARACTERS
    DATA RECORD IS TRANSACTION-RECORD.
01  TRANSACTION-RECORD                              PIC X(80).

FD  OLD-MASTER-FILE
    LABEL RECORDS ARE STANDARD
    BLOCK CONTAINS 0 RECORDS
    RECORD CONTAINS 80 CHARACTERS
    DATA RECORD IS OLD-MAST-RECORD.
01  OLD-MAST-RECORD                                 PIC X(80).

WORKING-STORAGE SECTION.
01  FILLER                                          PIC X(14)
        VALUE 'WS BEGINS HERE'.

01  WS-TRANS-RECORD.
    05  TR-SOC-SEC-NUMBER                           PIC X(9).
    05  TR-NAME.
        10  TR-LAST-NAME                            PIC X(15).
        10  TR-INITIALS                             PIC XX.
    05  TR-DATE-OF-BIRTH.
        10  TR-BIRTH-MONTH                          PIC 99.
        10  TR-BIRTH-YEAR                           PIC 99.
    05  TR-DATE-OF-HIRE.
        10  TR-HIRE-MONTH                           PIC 99.
        10  TR-HIRE-YEAR                            PIC 99.
    05  TR-LOCATION-CODE                            PIC X(3).
    05  TR-PERFORMANCE-CODE                         PIC X.
    05  TR-EDUCATION-CODE                           PIC X.
    05  TR-TITLE-DATA.
        10  TR-TITLE-CODE                           PIC 9(3).
        10  TR-TITLE-DATE                           PIC 9(4).
    05  TR-SALARY-DATA.
        10  TR-SALARY                               PIC 9(5).
        10  TR-SALARY-DATE                          PIC 9(4).
    05  TR-TRANSACTION-CODE                         PIC X.
        88  ADDITION        VALUE 'A'.
        88  CORRECTION      VALUE 'C'.
        88  DELETION        VALUE 'D'.
    05  FILLER                                      PIC X(24).
```

Two input files are required

Facilitates debugging

Three transaction types are permitted

STUBS PROGRAM (CONTINUED)

```
       01  WS-OLD-MAST-RECORD.
           05  OLD-SOC-SEC-NUMBER                PIC X(9).
           05  OLD-NAME.
               10  OLD-LAST-NAME                 PIC X(15).
               10  OLD-INITIALS                  PIC XX.
           05  OLD-DATE-OF-BIRTH.
               10  OLD-BIRTH-MONTH               PIC 99.
               10  OLD-BIRTH-YEAR                PIC 99.
           05  OLD-DATE-OF-HIRE.
               10  OLD-HIRE-MONTH                PIC 99.
               10  OLD-HIRE-HEAR                 PIC 99.
           05  OLD-LOCATION-CODE                 PIC X(3).
           05  OLD-PERFORMANCE-CODE              PIC X.
           05  OLD-EDUCATION-CODE                PIC X.
           05  OLD-TITLE-DATA OCCURS 2 TIMES.
               10  OLD-TITLE-CODE                PIC 9(3).
               10  OLD-TITLE-DATE                PIC 9(4).
           05  OLD-SALARY-DATA OCCURS 3 TIMES.
               10  OLD-SALARY                    PIC 9(5).
               10  OLD-SALARY-DATE               PIC 9(4).

       01  WS-BALANCE-LINE-SWITCHES.
           05  WS-ACTIVE-KEY                     PIC X(9).
           05  WS-RECORD-KEY-ALLOCATED-SWITCH    PIC X(3).

       PROCEDURE DIVISION.
       0010-UPDATE-MASTER-FILE.
           OPEN INPUT TRANSACTION-FILE
                      OLD-MASTER-FILE.
           PERFORM 0020-READ-TRANSACTION-FILE.
           PERFORM 0030-READ-OLD-MASTER-FILE.
           PERFORM 0040-CHOOSE-ACTIVE-KEY.
           PERFORM 0050-PROCESS-ACTIVE-KEY
               UNTIL WS-ACTIVE-KEY = HIGH-VALUES.
           CLOSE TRANSACTION-FILE
                 OLD-MASTER-FILE.
           STOP RUN.

       0020-READ-TRANSACTION-FILE.
           READ TRANSACTION-FILE INTO WS-TRANS-RECORD
               AT END MOVE HIGH-VALUES TO TR-SOC-SEC-NUMBER.

       0030-READ-OLD-MASTER-FILE.
           READ OLD-MASTER-FILE INTO WS-OLD-MAST-RECORD
               AT END MOVE HIGH-VALUE TO OLD-SOC-SEC-NUMBER.

       0040-CHOOSE-ACTIVE-KEY.
           IF TR-SOC-SEC-NUMBER LESS THAN OLD-SOC-SEC-NUMBER
               MOVE TR-SOC-SEC-NUMBER TO WS-ACTIVE-KEY
           ELSE
               MOVE OLD-SOC-SEC-NUMBER TO WS-ACTIVE-KEY.

       0050-PROCESS-ACTIVE-KEY.
           DISPLAY '     '.
           DISPLAY '     '.
           DISPLAY 'RECORDS BEING PROCESSED'.
           DISPLAY '  TRANSACTION SOC SEC #: ' TR-SOC-SEC-NUMBER.
           DISPLAY '  OLD MASTER SOC SEC #:  ' OLD-SOC-SEC-NUMBER.
           DISPLAY '  ACTIVE KEY:            ' WS-ACTIVE-KEY.
           DISPLAY '     '.
```

Initial reads (0020/0030 PERFORM statements)

Determines active key (0040-CHOOSE-ACTIVE-KEY)

DISPLAY statements to facilitate testing

STUBS PROGRAM (CONTINUED)

```
          IF OLD-SOC-SEC-NUMBER = WS-ACTIVE-KEY
              MOVE 'YES' TO WS-RECORD-KEY-ALLOCATED-SWITCH
              PERFORM 0060-BUILD-NEW-MASTER
          ELSE
              MOVE 'NO' TO WS-RECORD-KEY-ALLOCATED-SWITCH.

          PERFORM 0070-APPLY-TRANS-TO-MASTER
              UNTIL WS-ACTIVE-KEY NOT EQUAL TR-SOC-SEC-NUMBER.

          IF WS-RECORD-KEY-ALLOCATED-SWITCH = 'YES'
              PERFORM 0080-WRITE-NEW-MASTER.

          PERFORM 0040-CHOOSE-ACTIVE-KEY.

      0060-BUILD-NEW-MASTER.
          DISPLAY '0060-BUILD-NEW-MASTER ENTERED'.
          PERFORM 0030-READ-OLD-MASTER-FILE.

      0070-APPLY-TRANS-TO-MASTER.
          DISPLAY '0070-APPLY-TRANS-TO-MASTER ENTERED'
              '     TRANSACTION CODE: '  TR-TRANSACTION-CODE.
          IF ADDITION
              PERFORM 0090-ADD-NEW-RECORD
          ELSE
              IF CORRECTION
                  PERFORM 0100-CORRECT-OLD-RECORD
              ELSE
                  IF DELETION
                      PERFORM 0110-DELETE-OLD-RECORD.

          PERFORM 0020-READ-TRANSACTION-FILE.

      0080-WRITE-NEW-MASTER.
          DISPLAY '0080-WRITE-NEW-MASTER ENTERED'.

      0090-ADD-NEW-RECORD.
          DISPLAY '0090-ADD-NEW-RECORD ENTERED'.
          IF WS-RECORD-KEY-ALLOCATED-SWITCH = 'YES'
              DISPLAY '  ERROR-DUPLICATE ADDITION: ' TR-SOC-SEC-NUMBER
          ELSE
              MOVE 'YES' TO WS-RECORD-KEY-ALLOCATED-SWITCH.

      0100-CORRECT-OLD-RECORD.
          DISPLAY '0100-CORRECT-OLD-RECORD ENTERED'.
          IF WS-RECORD-KEY-ALLOCATED-SWITCH = 'YES'
              NEXT SENTENCE
          ELSE
              DISPLAY '  ERROR-NO MATCHING RECORD: ' TR-SOC-SEC-NUMBER.

      0110-DELETE-OLD-RECORD.
          DISPLAY '0110-DELETE-OLD-RECORD ENTERED'.
          IF WS-RECORD-KEY-ALLOCATED-SWITCH = 'YES'
              MOVE 'NO' TO WS-RECORD-KEY-ALLOCATED-SWITCH
          ELSE
              DISPLAY '  ERROR-NO MATCHING RECORD: ' TR-SOC-SEC-NUMBER.
```

Determines which lower level module to execute

Partially coded paragraph

Error check

TEST DATA

OLD MASTER FILE:

```
100000000SUGRUE      P 12450879100E53330880222087928000108126000 0980
200000000CRAWFORD    MA09430678100E64440678          420000680360000678
300000000MILGRUM     IR06130580200E655510614000681480000580
400000000BENJAMIN    BL10531073100E73331073          300001081280001080
500000000TATER       JS02500779200P43330779          310001081270000779
600000000GRAUER      RT11450877200E590011818001180500001181450001180
700000000JONES       A 09500778100G644407793330778390000881360000779
800000000SMITH       BB08520681300P84440681          385000681
900000000BAKER       E 06490879100G99870879          650000881550000879
```

TRANSACTION FILE:

Multiple transactions are permitted for the same old master reco

```
000000000BOROW          JS03431281100 99671281550001281A
000000000BOROW          JS              X              C
200000000CRAWFORD       MA09430678100E644406804200006 80A
400000000BENJAMIN       BL                             C
400000000BENJAMIN       BL1054                         C
400000000BENJAMIN       BL     1074                    C
400000001BENJAMIN       BL          200                C
500000000TATER          C                              D
555555555NEW EMPLOYEE   RT1145                         C
555555555NEW EMPLOYEE   RT11440681100E6444068139000068 1A
555555555NEW EMPLOYEE   RT                555          C
700000000JONES          A                      385000781C
800000000SMITH          BB                400          C
```

OUTPUT FROM STUBS PROGRAM

Active key is the smaller of old master and transaction keys

```
RECORDS BEING PROCESSED
  TRANSACTION SOC SEC #: 000000000
  OLD MASTER SOC SEC #:  100000000
  ACTIVE KEY:            000000000

0070-APPLY-TRANS-TO-MASTER ENTERED     TRANSACTION CODE: A
0090-ADD-NEW-RECORD ENTERED
0070-APPLY-TRANS-TO-MASTER ENTERED     TRANSACTION CODE: C
0100-CORRECT-OLD-RECORD ENTERED
0080-WRITE-NEW-MASTER ENTERED
```

Existing old master with no activity is copied to new master

```
RECORDS BEING PROCESSED
  TRANSACTION SOC SEC #: 200000000
  OLD MASTER SOC SEC #:  100000000
  ACTIVE KEY:            100000000

0060-BUILD-NEW-MASTER ENTERED
0080-WRITE-NEW-MASTER ENTERED
```

Duplicate addition is flagged

```
RECORDS BEING PROCESSED
  TRANSACTION SOC SEC #: 200000000
  OLD MASTER SOC SEC #:  200000000
  ACTIVE KEY:            200000000

0060-BUILD-NEW-MASTER ENTERED
0070-APPLY-TRANS-TO-MASTER ENTERED     TRANSACTION CODE: A
0090-ADD-NEW-RECORD ENTERED
  ERROR-DUPLICATE ADDITION: 200000000
0080-WRITE-NEW-MASTER ENTERED
```

```
RECORDS BEING PROCESSED
  TRANSACTION SOC SEC #: 400000000
  OLD MASTER SOC SEC #:  300000000
  ACTIVE KEY:            300000000

0060-BUILD-NEW-MASTER ENTERED
0080-WRITE-NEW-MASTER ENTERED
```

Three transactions are applied to same master record

```
RECORDS BEING PROCESSED
  TRANSACTION SOC SEC #: 400000000
  OLD MASTER SOC SEC #:  400000000
  ACTIVE KEY:            400000000

0060-BUILD-NEW-MASTER ENTERED
0070-APPLY-TRANS-TO-MASTER ENTERED     TRANSACTION CODE: C
0100-CORRECT-OLD-RECORD ENTERED
0070-APPLY-TRANS-TO-MASTER ENTERED     TRANSACTION CODE: C
0100-CORRECT-OLD-RECORD ENTERED
0070-APPLY-TRANS-TO-MASTER ENTERED     TRANSACTION CODE: C
0100-CORRECT-OLD-RECORD ENTERED
0080-WRITE-NEW-MASTER ENTERED
```

Error message indicating a miscopied social security number

```
RECORDS BEING PROCESSED
  TRANSACTION SOC SEC #: 400000001
  OLD MASTER SOC SEC #:  500000000
  ACTIVE KEY:            400000001

0070-APPLY-TRANS-TO-MASTER ENTERED     TRANSACTION CODE: C
0100-CORRECT-OLD-RECORD ENTERED
  ERROR-NO MATCHING RECORD: 400000001
```

STUBS OUTPUT (CONTINUED)

```
RECORDS BEING PROCESSED
  TRANSACTION SOC SEC #: 500000000
  OLD MASTER SOC SEC #:  500000000
  ACTIVE KEY:            500000000

0060-BUILD-NEW-MASTER ENTERED
0070-APPLY-TRANS-TO-MASTER ENTERED     TRANSACTION CODE: D
0110-DELETE-OLD-RECORD ENTERED


RECORDS BEING PROCESSED
  TRANSACTION SOC SEC #: 555555555
  OLD MASTER SOC SEC #:  600000000
  ACTIVE KEY:            555555555

0070-APPLY-TRANS-TO-MASTER ENTERED     TRANSACTION CODE: C
0100-CORRECT-OLD-RECORD ENTERED
  ERROR-NO MATCHING RECORD: 555555555
0070-APPLY-TRANS-TO-MASTER ENTERED     TRANSACTION CODE: A
0090-ADD-NEW-RECORD ENTERED
0070-APPLY-TRANS-TO-MASTER ENTERED     TRANSACTION CODE: C
0100-CORRECT-OLD-RECORD ENTERED
0080-WRITE-NEW-MASTER ENTERED
```

Attempted correction is flagged before addition is accomplished

Correction successfully applied *after* addition

```
RECORDS BEING PROCESSED
  TRANSACTION SOC SEC #: 700000000
  OLD MASTER SOC SEC #:  600000000
  ACTIVE KEY:            600000000

0060-BUILD-NEW-MASTER ENTERED
0080-WRITE-NEW-MASTER ENTERED


RECORDS BEING PROCESSED
  TRANSACTION SOC SEC #: 700000000
  OLD MASTER SOC SEC #:  700000000
  ACTIVE KEY:            700000000

0060-BUILD-NEW-MASTER ENTERED
0070-APPLY-TRANS-TO-MASTER ENTERED     TRANSACTION CODE: C
0100-CORRECT-OLD-RECORD ENTERED
0080-WRITE-NEW-MASTER ENTERED


RECORDS BEING PROCESSED
  TRANSACTION SOC SEC #: 800000000
  OLD MASTER SOC SEC #:  800000000
  ACTIVE KEY:            800000000

0060-BUILD-NEW-MASTER ENTERED
0070-APPLY-TRANS-TO-MASTER ENTERED     TRANSACTION CODE: C
0100-CORRECT-OLD-RECORD ENTERED
0080-WRITE-NEW-MASTER ENTERED
```

Transaction key has been set to HIGH-VALUES and does not print

```
RECORDS BEING PROCESSED
  TRANSACTION SOC SEC #:
  OLD MASTER SOC SEC #:  900000000
  ACTIVE KEY:            900000000

0060-BUILD-NEW-MASTER ENTERED
0080-WRITE-NEW-MASTER ENTERED
```

ONE IS NOW CONFIDENT THAT THE ESSENCE OF THE MAINTENANCE PROGRAM IS WORKING. IT IS RELATIVELY EASY TO FILL IN THE DETAILS OF THE LOWER LEVEL ROUTINES AND COMPLETE THE PROGRAM.

COMPLETED PROGRAM

```
       IDENTIFICATION DIVISION.
       PROGRAM-ID.    SEQUPDT.
       AUTHOR.        R. GRAUER.

       ENVIRONMENT DIVISION.
       CONFIGURATION SECTION.
       SOURCE-COMPUTER.      IBM-4341.
       OBJECT-COMPUTER.      IBM-4341.

       INPUT-OUTPUT SECTION.
       FILE-CONTROL.
           SELECT TRANSACTION-FILE
               ASSIGN TO UT-S-TRANS.
           SELECT OLD-MASTER-FILE
               ASSIGN TO UT-S-MASTER.
           SELECT NEW-MASTER-FILE
               ASSIGN TO UT-S-NEWMAST.

       DATA DIVISION.
       FILE SECTION.
       FD  TRANSACTION-FILE
           LABEL RECORDS ARE STANDARD
           BLOCK CONTAINS 0 RECORDS
           RECORD CONTAINS 80 CHARACTERS
           DATA RECORD IS TRANSACTION-RECORD.
       01  TRANSACTION-RECORD                              PIC X(80).

       FD  OLD-MASTER-FILE
           LABEL RECORDS ARE STANDARD
           BLOCK CONTAINS 0 RECORDS
           RECORD CONTAINS 80 CHARACTERS
           DATA RECORD IS OLD-MAST-RECORD.
       01  OLD-MAST-RECORD                                 PIC X(80).

       FD  NEW-MASTER-FILE
           LABEL RECORDS ARE STANDARD
           BLOCK CONTAINS 0 RECORDS
           RECORD CONTAINS 80 CHARACTERS
           DATA RECORD IS NEW-MAST-RECORD.
       01  NEW-MAST-RECORD                                 PIC X(80).

       WORKING-STORAGE SECTION.
       01  FILLER                                          PIC X(14)
               VALUE 'WS BEGINS HERE'.

       01  WS-TRANS-RECORD.
           05  TR-SOC-SEC-NUMBER                           PIC X(9).
           05  TR-NAME.
               10  TR-LAST-NAME                            PIC X(15).
               10  TR-INITIALS                             PIC XX.
           05  TR-DATE-OF-BIRTH.
               10  TR-BIRTH-MONTH                          PIC 99.
               10  TR-BIRTH-YEAR                           PIC 99.
           05  TR-DATE-OF-HIRE.
               10  TR-HIRE-MONTH                           PIC 99.
               10  TR-HIRE-YEAR                            PIC 99.
           05  TR-LOCATION-CODE                            PIC X(3).
           05  TR-PERFORMANCE-CODE                         PIC X.
           05  TR-EDUCATION-CODE                           PIC X.
           05  TR-TITLE-DATA.
               10  TR-TITLE-CODE                           PIC 9(3).
               10  TR-TITLE-DATE                           PIC 9(4).
           05  TR-SALARY-DATA.
               10  TR-SALARY                               PIC 9(5).
               10  TR-SALARY-DATE                          PIC 9(4).
           05  TR-TRANSACTION-CODE                         PIC X.
               88  ADDITION          VALUE 'A'.
               88  CORRECTION        VALUE 'C'.
               88  DELETION          VALUE 'D'.
           05  FILLER                                      PIC X(24).
```

Output file has been added (boxed: SELECT NEW-MASTER-FILE / ASSIGN TO UT-S-NEWMAST.)

Three transaction types (boxed: 88 ADDITION, 88 CORRECTION, 88 DELETION)

```
       01  WS-OLD-MAST-RECORD.
           05  OLD-SOC-SEC-NUMBER                    PIC X(9).
           05  OLD-NAME.
               10  OLD-LAST-NAME                     PIC X(15).
               10  OLD-INITIALS                      PIC XX.
           05  OLD-DATE-OF-BIRTH.
               10  OLD-BIRTH-MONTH                   PIC 99.
               10  OLD-BIRTH-YEAR                    PIC 99.
           05  OLD-DATE-OF-HIRE.
               10  OLD-HIRE-MONTH                    PIC 99.
               10  OLD-HIRE-HEAR                     PIC 99.
           05  OLD-LOCATION-CODE                     PIC X(3).
           05  OLD-PERFORMANCE-CODE                  PIC X.
           05  OLD-EDUCATION-CODE                    PIC X.
           05  OLD-TITLE-DATA OCCURS 2 TIMES.
               10  OLD-TITLE-CODE                    PIC 9(3).
               10  OLD-TITLE-DATE                    PIC 9(4).
           05  OLD-SALARY-DATA OCCURS 3 TIMES.
               10  OLD-SALARY                        PIC 9(5).
               10  OLD-SALARY-DATE                   PIC 9(4).

       01  WS-NEW-MAST-RECORD.
           05  NEW-SOC-SEC-NUMBER                    PIC X(9).
           05  NEW-NAME.
               10  NEW-LAST-NAME                     PIC X(15).
               10  NEW-INITIALS                      PIC XX.
           05  NEW-DATE-OF-BIRTH.
               10  NEW-BIRTH-MONTH                   PIC 99.
               10  NEW-BIRTH-YEAR                    PIC 99.
           05  NEW-DATE-OF-HIRE.
               10  NEW-HIRE-MONTH                    PIC 99.
               10  NEW-HIRE-HEAR                     PIC 99.
           05  NEW-LOCATION-CODE                     PIC X(3).
           05  NEW-PERFORMANCE-CODE                  PIC X.
           05  NEW-EDUCATION-CODE                    PIC X.
           05  NEW-TITLE-DATA OCCURS 2 TIMES.
               10  NEW-TITLE-CODE                    PIC 9(3).
               10  NEW-TITLE-DATE                    PIC 9(4).
           05  NEW-SALARY-DATA OCCURS 3 TIMES.
               10  NEW-SALARY                        PIC 9(5).
               10  NEW-SALARY-DATE                   PIC 9(4).

       01  WS-BALANCE-LINE-SWITCHES.
           05  WS-ACTIVE-KEY                         PIC X(9).
           05  WS-RECORD-KEY-ALLOCATED-SWITCH        PIC X(3).

       PROCEDURE DIVISION.
       0010-UPDATE-MASTER-FILE.
           OPEN INPUT TRANSACTION-FILE
                      OLD-MASTER-FILE
               OUTPUT NEW-MASTER-FILE.
           PERFORM 0020-READ-TRANSACTION-FILE.
           PERFORM 0030-READ-OLD-MASTER-FILE.
           PERFORM 0040-CHOOSE-ACTIVE-KEY.
           PERFORM 0050-PROCESS-ACTIVE-KEY
               UNTIL WS-ACTIVE-KEY = HIGH-VALUES.
           CLOSE TRANSACTION-FILE
                 OLD-MASTER-FILE
                 NEW-MASTER-FILE.
           STOP RUN.

       0020-READ-TRANSACTION-FILE.
           READ TRANSACTION-FILE INTO WS-TRANS-RECORD
               AT END MOVE HIGH-VALUES TO TR-SOC-SEC-NUMBER.

       0030-READ-OLD-MASTER-FILE.
           READ OLD-MASTER-FILE INTO WS-OLD-MAST-RECORD
               AT END MOVE HIGH-VALUE TO OLD-SOC-SEC-NUMBER.

       0040-CHOOSE-ACTIVE-KEY.
           IF TR-SOC-SEC-NUMBER LESS THAN OLD-SOC-SEC-NUMBER
               MOVE TR-SOC-SEC-NUMBER TO WS-ACTIVE-KEY
           ELSE
               MOVE OLD-SOC-SEC-NUMBER TO WS-ACTIVE-KEY.
```

Record layouts are identical

Processing terminates when the active key is HIGH-VALUES; i.e., when both files are empty

```
00147       0050-PROCESS-ACTIVE-KEY.
00148           IF OLD-SOC-SEC-NUMBER = WS-ACTIVE-KEY
00149               MOVE 'YES' TO WS-RECORD-KEY-ALLOCATED-SWITCH
00150               PERFORM 0060-BUILD-NEW-MASTER
00151           ELSE
00152               MOVE 'NO' TO WS-RECORD-KEY-ALLOCATED-SWITCH.
00153
00154           PERFORM 0070-APPLY-TRANS-TO-MASTER
00155               UNTIL WS-ACTIVE-KEY NOT EQUAL TR-SOC-SEC-NUMBER.
00156
00157           IF WS-RECORD-KEY-ALLOCATED-SWITCH = 'YES'
00158               PERFORM 0080-WRITE-NEW-MASTER.
00159
00160           PERFORM 0040-CHOOSE-ACTIVE-KEY.
00161
00162       0060-BUILD-NEW-MASTER.
00163           MOVE WS-OLD-MAST-RECORD TO WS-NEW-MAST-RECORD.
00164           PERFORM 0030-READ-OLD-MASTER-FILE.
00165
00166       0070-APPLY-TRANS-TO-MASTER.
00167           IF ADDITION
00168               PERFORM 0090-ADD-NEW-RECORD
00169           ELSE
00170               IF CORRECTION
00171                   PERFORM 0100-CORRECT-OLD-RECORD
00172               ELSE
00173                   IF DELETION
00174                       PERFORM 0110-DELETE-OLD-RECORD.
00175
00176           PERFORM 0020-READ-TRANSACTION-FILE.
00177
00178       0080-WRITE-NEW-MASTER.
00179           WRITE NEW-MAST-RECORD FROM WS-NEW-MAST-RECORD.
00180
00181       0090-ADD-NEW-RECORD.
00182           IF WS-RECORD-KEY-ALLOCATED-SWITCH = 'YES'
00183               DISPLAY '  ERROR-DUPLICATE ADDITION: ' TR-SOC-SEC-NUMBER
00184           ELSE
00185               MOVE 'YES' TO WS-RECORD-KEY-ALLOCATED-SWITCH
00186               MOVE SPACES TO WS-NEW-MAST-RECORD
00187               MOVE TR-SOC-SEC-NUMBER TO NEW-SOC-SEC-NUMBER
00188               MOVE TR-NAME TO NEW-NAME
00189               MOVE TR-DATE-OF-BIRTH TO NEW-DATE-OF-BIRTH
00190               MOVE TR-DATE-OF-HIRE TO NEW-DATE-OF-HIRE
00191               MOVE TR-LOCATION-CODE TO NEW-LOCATION-CODE
00192               MOVE TR-PERFORMANCE-CODE TO NEW-PERFORMANCE-CODE
00193               MOVE TR-EDUCATION-CODE TO NEW-EDUCATION-CODE
00194               MOVE TR-TITLE-DATA TO NEW-TITLE-DATA (1)
00195               MOVE TR-SALARY-DATA TO NEW-SALARY-DATA (1).
00196
00197       0100-CORRECT-OLD-RECORD.
00198           IF WS-RECORD-KEY-ALLOCATED-SWITCH = 'YES'
00199               PERFORM 0105-CORRECT-INDIVIDUAL-FIELDS
00200           ELSE
00201               DISPLAY '  ERROR-NO MATCHING RECORD: ' TR-SOC-SEC-NUMBER.
00202
00203       0105-CORRECT-INDIVIDUAL-FIELDS.
00204           IF TR-NAME NOT EQUAL SPACES
00205               MOVE TR-NAME TO NEW-NAME.
00206           IF TR-DATE-OF-BIRTH NOT EQUAL SPACES
00207               MOVE TR-DATE-OF-BIRTH TO NEW-DATE-OF-BIRTH.
00208           IF TR-DATE-OF-HIRE NOT EQUAL SPACES
00209               MOVE TR-DATE-OF-HIRE TO NEW-DATE-OF-HIRE.
00210           IF TR-LOCATION-CODE NOT EQUAL SPACES
00211               MOVE TR-LOCATION-CODE TO NEW-LOCATION-CODE.
00212           IF  TR-PERFORMANCE-CODE NOT EQUAL SPACES
00213               MOVE TR-PERFORMANCE-CODE TO NEW-PERFORMANCE-CODE.
00214           IF TR-EDUCATION-CODE NOT EQUAL SPACES
00215               MOVE TR-EDUCATION-CODE TO NEW-EDUCATION-CODE.
00216           IF TR-TITLE-CODE IS NUMERIC
00217               MOVE TR-TITLE-CODE TO NEW-TITLE-CODE (1).
00218           IF TR-TITLE-DATE IS NUMERIC
00219               MOVE TR-TITLE-DATE TO NEW-TITLE-DATE (1).
00220           IF TR-SALARY IS NUMERIC
00221               MOVE TR-SALARY TO NEW-SALARY (1).
00222           IF TR-SALARY-DATE IS NUMERIC
00223               MOVE TR-SALARY-DATE TO NEW-SALARY-DATE (1).
00224
00225       0110-DELETE-OLD-RECORD.
00226           IF WS-RECORD-KEY-ALLOCATED-SWITCH = 'YES'
00227               MOVE 'NO' TO WS-RECORD-KEY-ALLOCATED-SWITCH
00228           ELSE
00229               DISPLAY '  ERROR-NO MATCHING RECORD: ' TR-SOC-SEC-NUMBER.
```

Applies multipl transactions to a single master record (lines 154–155)

Expanded from a program stub (lines 181–195)

Precludes writing new master and delete record (see lines 157-158) (lines 226–227)

OUTPUT OF SEQUENTIAL UPDATE

NEW MASTER:

This record has been added

Two fields have been corrected from two different transactions

```
000000000BUROW        JS03431281100X99871281         550001281
100000000SUGRUE       P 12450879100E5333088022208792800010812600009800
200000000CRAWFORD     MA09430678100E64440678         420000680360000678
300000000MILGROM      IR06130580200E65551081400068148000058O
400000000BENJAMIN     BL10541074100E73331073         300001081280001080
555555555NEW EMPLOYEE RT11440681100E65550681         390000681
600000000GRAUER       RT11450877200E5900118180011805000011814500011 80
700000000JONES        A 09500778100G644407793330778385000781360000779
800000000SMITH        BB08520681300P84000681         385000681
900000000BAKER        E 06490879100G99870879         650000881550000879
```

Social Security Number 500000000 has been deleted

ERROR MESSAGES:

```
ERROR-DUPLICATE ADDITION: 200000000
ERROR-NO MATCHING RECORD: 400000001
ERROR-NO MATCHING RECORD: 555555555
```

Pertains to first transaction for this record

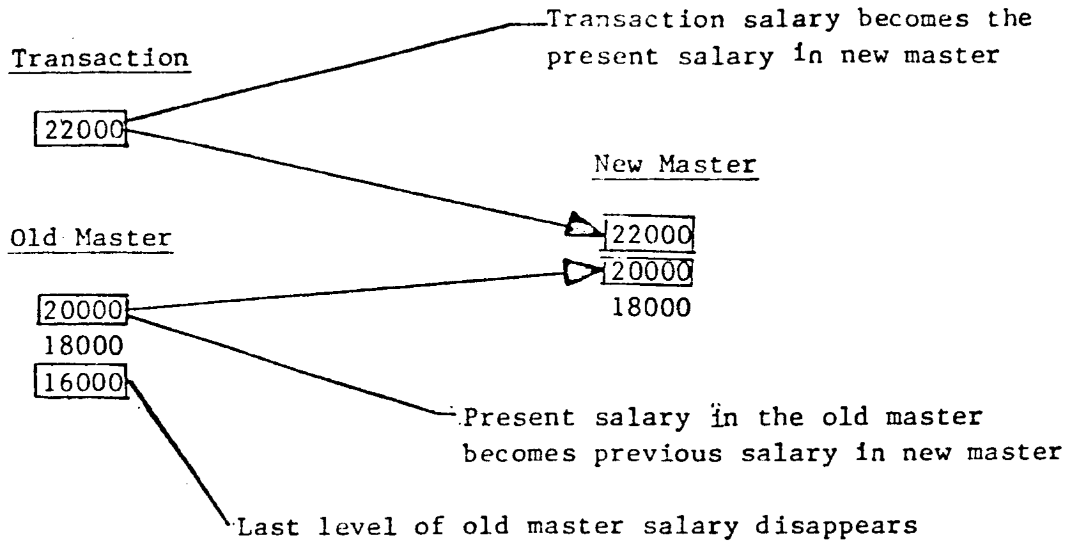
PROGRAM MAINTENANCE:

A WELL WRITTEN PROGRAM SHOULD BE EASILY READ AND MAINTAINED BY SOMEONE OTHER THAN THE ORIGINAL AUTHOR. WE WILL PROVE THE EFFECTIVENESS OF THE STRUCTURED METHODS THROUGH THE FOLLOWING CHANGES:

1. INCLUSION OF A SECOND TRANSACTION FILE FOR PROMOTIONS AND/OR SALARY INCREASES:

```
01  PROMOTION-RECORD.
    05  PR-SOC-SEC-NUMBER              PIC X(9).
    05  PR-NAME.
        10  PR-LAST-NAME               PIC X(15).
        10  PR-INITIALS                PIC XX.
    05  PR-SALARY-DATA.
        10  PR-SALARY                  PIC 9(5).
        10  PR-SALARY-DATE             PIC 9(4).
    05  PR-TITLE-DATA.
        10  PR-TITLE-CODE              PIC 9(3).
        10  PR-TITLE-DATE              PIC 9(4).
    05  PR-PROMOTION-CODE              PIC X.
        88  SALARY-RAISE           VALUE 'R'.
        88  PROMOTION              VALUE 'P'.
    05  FILLER                         PIC X(37).
```

2. SALARY INCREASES ARE HANDLED IN THE FOLLOWING MANNER:

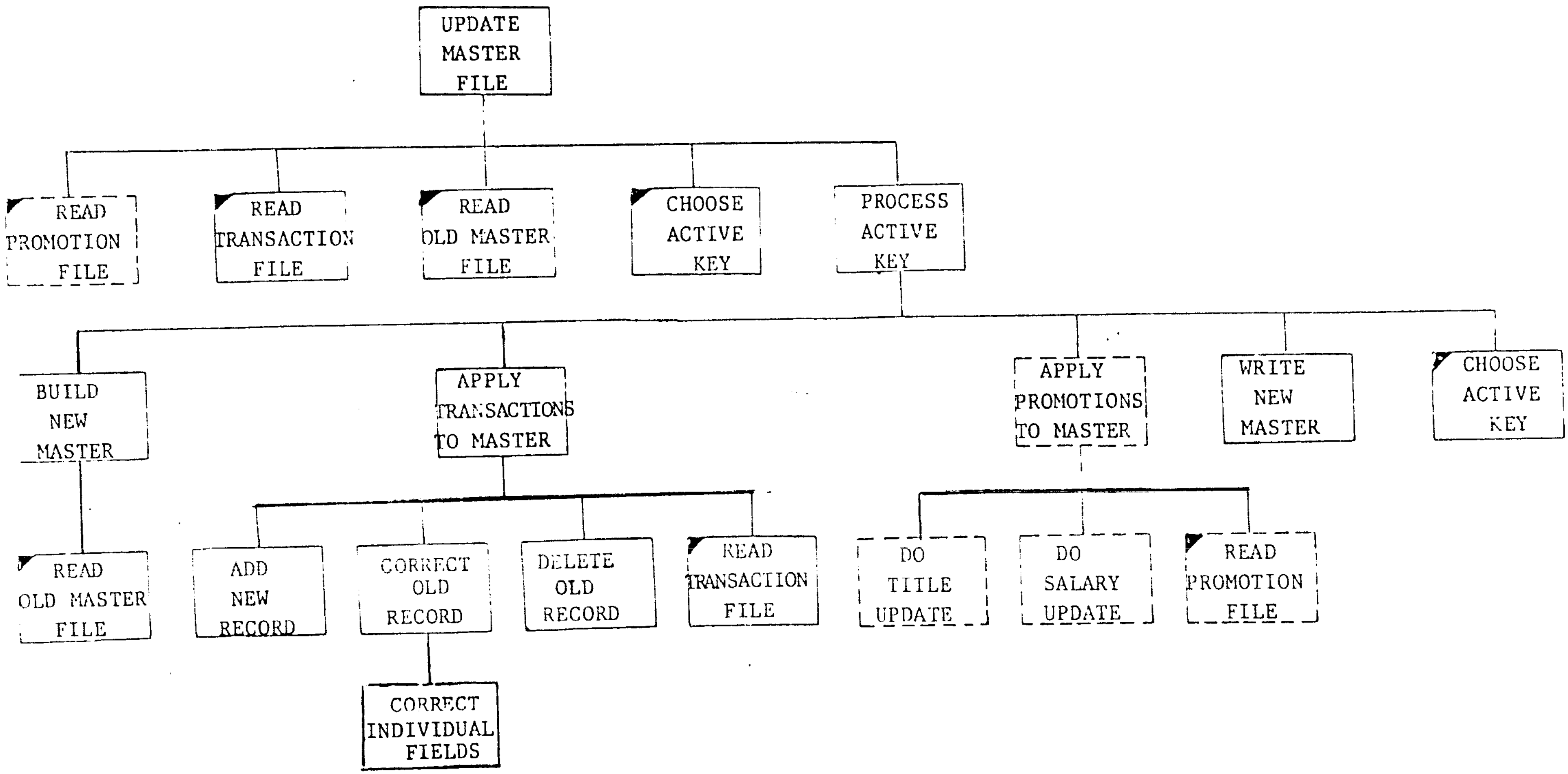


3. PROMOTIONS (I.E., TITLE CHANGES) ARE PROCESSED IN AN ANALOGOUS MANNER

4. DELETIONS ARE TO BE WRITTEN IN THEIR ENTIRETY TO A NEW FILE

5. ERROR MESSAGES ARE TO PRINT THE ENTIRE TRANSACTION IN ERROR

EXPANDED HIERARCHY CHART



NOTES:

1. DOTTED LINES INDICATE NEW MODULES REQUIRED AS A RESULT OF MODIFICATIONS.
2. SOME EXISTING MODULES WILL REQUIRE MODIFICATION.

MODIFIED SEQUENTIAL UPDATE

```
       IDENTIFICATION DIVISION.
       PROGRAM-ID.    SEQUPEX.
       AUTHOR.        R. GRAUER.

       ENVIRONMENT DIVISION.
       CONFIGURATION SECTION.
       SOURCE-COMPUTER.      IBM-4341.
       OBJECT-COMPUTER.      IBM-4341.

       INPUT-OUTPUT SECTION.
       FILE-CONTROL.
           SELECT TRANSACTION-FILE
               ASSIGN TO UT-S-TRANS.
           SELECT OLD-MASTER-FILE
               ASSIGN TO UT-S-MASTER.
           SELECT PROMOTION-FILE
               ASSIGN TO UT-S-PROMOTE.
           SELECT DELETED-RECORD-FILE
               ASSIGN TO UT-S-DELETE.
           SELECT NEW-MASTER-FILE
               ASSIGN TO UT-S-NEWMAST.

       DATA DIVISION.
       FILE SECTION.
       FD  TRANSACTION-FILE
           LABEL RECORDS ARE STANDARD
           BLOCK CONTAINS 0 RECORDS
           RECORD CONTAINS 80 CHARACTERS
           DATA RECORD IS TRANSACTION-RECORD.
       01  TRANSACTION-RECORD                      PIC X(80).

       FD  OLD-MASTER-FILE
           LABEL RECORDS ARE STANDARD
           BLOCK CONTAINS 0 RECORDS
           RECORD CONTAINS 80 CHARACTERS
           DATA RECORD IS OLD-MAST-RECORD.
       01  OLD-MAST-RECORD                         PIC X(80).

       FD  PROMOTION-FILE
           LABEL RECORDS ARE STANDARD
           BLOCK CONTAINS 0 RECORDS
           RECORD CONTAINS 80 CHARACTERS
           DATA RECORD IS PROMOTION-RECORD.
       01  PROMOTION-RECORD                        PIC X(80).

       FD  DELETED-RECORD-FILE
           LABEL RECORDS ARE STANDARD
           BLOCK CONTAINS 0 RECORDS
           RECORD CONTAINS 80 CHARACTERS
           DATA RECORD IS DELETED-RECORD.
       01  DELETED-RECORD                          PIC X(80).

       FD  NEW-MASTER-FILE
           LABEL RECORDS ARE STANDARD
           BLOCK CONTAINS 0 RECORDS
           RECORD CONTAINS 80 CHARACTERS
           DATA RECORD IS NEW-MAST-RECORD.
       01  NEW-MAST-RECORD                         PIC X(80).

       WORKING-STORAGE SECTION.
       01  FILLER                                  PIC X(14)
               VALUE 'WS BEGINS HERE'.
```

Promotion file has been added

```
       01  WS-TRANS-RECORD.
           05  TR-SOC-SEC-NUMBER                      PIC X(9).
           05  TR-NAME.
               10  TR-LAST-NAME                       PIC X(15).
               10  TR-INITIALS                        PIC XX.
           05  TR-DATE-OF-BIRTH.
               10  TR-BIRTH-MONTH                     PIC 99.
               10  TR-BIRTH-YEAR                      PIC 99.
           05  TR-DATE-OF-HIRE.
               10  TR-HIRE-MONTH                      PIC 99.
               10  TR-HIRE-YEAR                       PIC 99.
           05  TR-LOCATION-CODE                       PIC X(3).
           05  TR-PERFORMANCE-CODE                    PIC X.
           05  TR-EDUCATION-CODE                      PIC X.
           05  TR-TITLE-DATA.
               10  TR-TITLE-CODE                      PIC 9(3).
               10  TR-TITLE-DATE                      PIC 9(4).
           05  TR-SALARY-DATA.
               10  TR-SALARY                          PIC 9(5).
               10  TR-SALARY-DATE                     PIC 9(4).
           05  TR-TRANSACTION-CODE                    PIC X.
               88  ADDITION          VALUE 'A'.
               88  CORRECTION        VALUE 'C'.
               88  DELETION          VALUE 'D'.
           05  FILLER                                 PIC X(24).

       01  WS-PROMOTION-RECORD.
           05  PR-SOC-SEC-NUMBER                      PIC X(9).
           05  PR-NAME.
               10  PR-LAST-NAME                       PIC X(15).
               10  PR-INITIALS                        PIC XX.
           05  PR-SALARY-DATA.
               10  PR-SALARY                          PIC 9(5).
               10  PR-SALARY-DATE                     PIC 9(4).
           05  PR-TITLE-DATA.
               10  PR-TITLE-CODE                      PIC 9(3).
               10  PR-TITLE-DATE                      PIC 9(4).
           05  PR-PROMOTION-CODE                      PIC X.
               88  SALARY-RAISE      VALUE 'R'.
               88  PROMOTION         VALUE 'P'.
           05  FILLER                                 PIC X(37).

       01  WS-OLD-MAST-RECORD.
           05  OLD-SOC-SEC-NUMBER                     PIC X(9).
           05  OLD-NAME.
               10  OLD-LAST-NAME                      PIC X(15).
               10  OLD-INITIALS                       PIC XX.
           05  OLD-DATE-OF-BIRTH.
               10  OLD-BIRTH-MONTH                    PIC 99.
               10  OLD-BIRTH-YEAR                     PIC 99.
           05  OLD-DATE-OF-HIRE.
               10  OLD-HIRE-MONTH                     PIC 99.
               10  OLD-HIRE-HEAR                      PIC 99.
           05  OLD-LOCATION-CODE                      PIC X(3).
           05  OLD-PERFORMANCE-CODE                   PIC X.
           05  OLD-EDUCATION-CODE                     PIC X.
           05  OLD-TITLE-DATA OCCURS 2 TIMES.
               10  OLD-TITLE-CODE                     PIC 9(3).
               10  OLD-TITLE-DATE                     PIC 9(4).
           05  OLD-SALARY-DATA OCCURS 3 TIMES.
               10  OLD-SALARY                         PIC 9(5).
               10  OLD-SALARY-DATE                    PIC 9(4).
```

Two levels of title da

Three levels of salar data

```
01  WS-NEW-MAST-RECORD.
    05  NEW-SOC-SEC-NUMBER                 PIC X(9).
    05  NEW-NAME.
        10  NEW-LAST-NAME                  PIC X(15).
        10  NEW-INITIALS                   PIC XX.
    05  NEW-DATE-OF-BIRTH.
        10  NEW-BIRTH-MONTH                PIC 99.
        10  NEW-BIRTH-YEAR                 PIC 99.
    05  NEW-DATE-OF-HIRE.
        10  NEW-HIRE-MONTH                 PIC 99.
        10  NEW-HIRE-HEAR                  PIC 99.
    05  NEW-LOCATION-CODE                  PIC X(3).
    05  NEW-PERFORMANCE-CODE               PIC X.
    05  NEW-EDUCATION-CODE                 PIC X.
    05  NEW-TITLE-DATA OCCURS 2 TIMES.
        10  NEW-TITLE-CODE                 PIC 9(3).
        10  NEW-TITLE-DATE                 PIC 9(4).
    05  NEW-SALARY-DATA OCCURS 3 TIMES.
        10  NEW-SALARY                     PIC 9(5).
        10  NEW-SALARY-DATE                PIC 9(4).

01  WS-BALANCE-LINE-SWITCHES.
    05  WS-ACTIVE-KEY                      PIC X(9).
    05  WS-RECORD-KEY-ALLOCATED-SWITCH     PIC X(3).

PROCEDURE DIVISION.
0010-UPDATE-MASTER-FILE.
    OPEN INPUT TRANSACTION-FILE
               PROMOTION-FILE
               OLD-MASTER-FILE
        OUTPUT NEW-MASTER-FILE
               DELETED-RECORD-FILE.
    PERFORM 0015-READ-PROMOTION-FILE.
    PERFORM 0020-READ-TRANSACTION-FILE.
    PERFORM 0030-READ-OLD-MASTER-FILE.
    PERFORM 0040-CHOOSE-ACTIVE-KEY.
    PERFORM 0050-PROCESS-ACTIVE-KEY
        UNTIL WS-ACTIVE-KEY = HIGH-VALUES.
    CLOSE TRANSACTION-FILE
          PROMOTION-FILE
          OLD-MASTER-FILE
          NEW-MASTER-FILE
          DELETED-RECORD-FILE.
    STOP RUN.

0015-READ-PROMOTION-FILE.
    READ PROMOTION-FILE INTO WS-PROMOTION-RECORD
        AT END MOVE HIGH-VALUES TO PR-SOC-SEC-NUMBER.

0020-READ-TRANSACTION-FILE.
    READ TRANSACTION-FILE INTO WS-TRANS-RECORD
        AT END MOVE HIGH-VALUES TO TR-SOC-SEC-NUMBER.

0030-READ-OLD-MASTER-FILE.
    READ OLD-MASTER-FILE INTO WS-OLD-MAST-RECORD
        AT END MOVE HIGH-VALUE TO OLD-SOC-SEC-NUMBER.

0040-CHOOSE-ACTIVE-KEY.
    IF TR-SOC-SEC-NUMBER LESS THAN OLD-SOC-SEC-NUMBER
        IF TR-SOC-SEC-NUMBER LESS THAN PR-SOC-SEC-NUMBER
            MOVE TR-SOC-SEC-NUMBER TO WS-ACTIVE-KEY
        ELSE
            MOVE PR-SOC-SEC-NUMBER TO WS-ACTIVE-KEY
    ELSE
        IF PR-SOC-SEC-NUMBER LESS THAN OLD-SOC-SEC-NUMBER
            MOVE PR-SOC-SEC-NUMBER TO WS-ACTIVE-KEY
        ELSE
            MOVE OLD-SOC-SEC-NUMBER TO WS-ACTIVE-KEY.
```

Logic expanded to include PROMOTION-FILE

```
0050-PROCESS-ACTIVE-KEY.
    IF OLD-SOC-SEC-NUMBER = WS-ACTIVE-KEY
        MOVE 'YES' TO WS-RECORD-KEY-ALLOCATED-SWITCH
        PERFORM 0060-BUILD-NEW-MASTER
    ELSE
        MOVE 'NO' TO WS-RECORD-KEY-ALLOCATED-SWITCH.

    PERFORM 0070-APPLY-TRANS-TO-MASTER
        UNTIL WS-ACTIVE-KEY NOT EQUAL TR-SOC-SEC-NUMBER.

    PERFORM 0075-APPLY-PROMO-TO-MASTER
        UNTIL WS-ACTIVE-KEY NOT EQUAL PR-SOC-SEC-NUMBER.

    IF WS-RECORD-KEY-ALLOCATED-SWITCH = 'YES'
        PERFORM 0080-WRITE-NEW-MASTER.

    PERFORM 0040-CHOOSE-ACTIVE-KEY.

0060-BUILD-NEW-MASTER.
    MOVE WS-OLD-MAST-RECORD TO WS-NEW-MAST-RECORD.
    PERFORM 0030-READ-OLD-MASTER-FILE.

0070-APPLY-TRANS-TO-MASTER.
    IF ADDITION
        PERFORM 0090-ADD-NEW-RECORD
    ELSE
        IF CORRECTION
            PERFORM 0100-CORRECT-OLD-RECORD
        ELSE
            IF DELETION
                PERFORM 0110-DELETE-OLD-RECORD.

    PERFORM 0020-READ-TRANSACTION-FILE.

0075-APPLY-PROMO-TO-MASTER.
```

Intermediate level module has been added

```
    IF PROMOTION
        PERFORM 0120-DO-TITLE-UPDATE
    ELSE
        IF SALARY-RAISE
            PERFORM 0130-DO-SALARY-RAISE.

    PERFORM 0015-READ-PROMOTION-FILE.

0080-WRITE-NEW-MASTER.
    WRITE NEW-MAST-RECORD FROM WS-NEW-MAST-RECORD.

0090-ADD-NEW-RECORD.
    IF WS-RECORD-KEY-ALLOCATED-SWITCH = 'YES'
        DISPLAY '     '
        DISPLAY '   ERROR DUPLICATE ADDITION: '
        DISPLAY '      TRANSACTION IN ERROR: ' WS-TRANS-RECORD
```

Error messages are better formatt

```
    ELSE
        MOVE 'YES' TO WS-RECORD-KEY-ALLOCATED-SWITCH
        MOVE SPACES TO WS-NEW-MAST-RECORD
        MOVE TR-SOC-SEC-NUMBER TO NEW-SOC-SEC-NUMBER
        MOVE TR-NAME TO NEW-NAME
        MOVE TR-DATE-OF-BIRTH TO NEW-DATE-OF-BIRTH
        MOVE TR-DATE-OF-HIRE TO NEW-DATE-OF-HIRE
        MOVE TR-LOCATION-CODE TO NEW-LOCATION-CODE
        MOVE TR-PERFORMANCE-CODE TO NEW-PERFORMANCE-CODE
        MOVE TR-EDUCATION-CODE TO NEW-EDUCATION-CODE
        MOVE TR-TITLE-DATA TO NEW-TITLE-DATA (1)
        MOVE TR-SALARY-DATA TO NEW-SALARY-DATA (1).
```

```
0100-CORRECT-OLD-RECORD.
    IF WS-RECORD-KEY-ALLOCATED-SWITCH = 'YES'
        PERFORM 0105-CORRECT-INDIVIDUAL-FIELDS
    ELSE
        DISPLAY '     '
        DISPLAY '  ERROR-NO MATCHING RECORD: '
        DISPLAY '    TRANSACTION IN ERROR: ' WS-TRANS-RECORD.

0105-CORRECT-INDIVIDUAL-FIELDS.
    IF TR-NAME NOT EQUAL SPACES
        MOVE TR-NAME TO NEW-NAME.
    IF TR-DATE-OF-BIRTH NOT EQUAL SPACES
        MOVE TR-DATE-OF-BIRTH TO NEW-DATE-OF-BIRTH.
    IF TR-DATE-OF-HIRE NOT EQUAL SPACES
        MOVE TR-DATE-OF-HIRE TO NEW-DATE-OF-HIRE.
    IF TR-LOCATION-CODE NOT EQUAL SPACES
        MOVE TR-LOCATION-CODE TO NEW-LOCATION-CODE.
    IF  TR-PERFORMANCE-CODE NOT EQUAL SPACES
        MOVE TR-PERFORMANCE-CODE TO NEW-PERFORMANCE-CODE.
    IF TR-EDUCATION-CODE NOT EQUAL SPACES
        MOVE TR-EDUCATION-CODE TO NEW-EDUCATION-CODE.
    IF TR-TITLE-CODE IS NUMERIC
        MOVE TR-TITLE-CODE TO NEW-TITLE-CODE (1).
    IF TR-TITLE-DATE IS NUMERIC
        MOVE TR-TITLE-DATE TO NEW-TITLE-DATE (1).
    IF TR-SALARY IS NUMERIC
        MOVE TR-SALARY TO NEW-SALARY (1).
    IF TR-SALARY-DATE IS NUMERIC
        MOVE TR-SALARY-DATE TO NEW-SALARY-DATE (1).

0110-DELETE-OLD-RECORD.
    IF WS-RECORD-KEY-ALLOCATED-SWITCH = 'YES'
        MOVE 'NO' TO WS-RECORD-KEY-ALLOCATED-SWITCH
        WRITE DELETED-RECORD FROM WS-NEW-MAST-RECORD
    ELSE
        DISPLAY '     '
        DISPLAY '  ERROR-NO MATCHING RECORD: '
        DISPLAY '    TRANSACTION IN ERROR: ' WS-TRANS-RECORD.

0120-DO-TITLE-UPDATE.
    IF WS-RECORD-KEY-ALLOCATED-SWITCH = 'YES'
        MOVE NEW-TITLE-CODE (1) TO NEW-TITLE-CODE (2)
        MOVE NEW-TITLE-DATE (1) TO NEW-TITLE-DATE (2)
        MOVE PR-TITLE-CODE TO NEW-TITLE-CODE (1)
        MOVE PR-TITLE-DATE TO NEW-TITLE-DATE (1)
    ELSE
        DISPLAY '     '
        DISPLAY '  ERROR-NO MATCHING RECORD: '
        DISPLAY '    PROMOTION IN ERROR: ' WS-PROMOTION-RECORD.

0130-DO-SALARY-RAISE.
    IF WS-RECORD-KEY-ALLOCATED-SWITCH = 'YES'
        MOVE NEW-SALARY (2) TO NEW-SALARY (3)
        MOVE NEW-SALARY-DATE (2) TO NEW-SALARY-DATE (3)
        MOVE NEW-SALARY (1) TO NEW-SALARY (2)
        MOVE NEW-SALARY-DATE (1) TO NEW-SALARY-DATE (2)
        MOVE PR-SALARY TO NEW-SALARY (1)
        MOVE PR-SALARY-DATE TO NEW-SALARY-DATE (1)
    ELSE
        DISPLAY '     '
        DISPLAY '  ERROR-NO MATCHING RECORD: '
        DISPLAY '    PROMOTION IN ERROR: ' WS-PROMOTION-RECORD.
```

Deleted records are written to a new file

Low level modules have been added

INPUT TO MODIFIED SEQUENTIAL UPDATE

TRANSACTION FILE:

```
000000000BOROW           JS03431281100 998712815500001281A
000000000BOROW           JS                 X               C
200000000CRAWFORD        MA0943067810OE64440680420000680A
400000000BENJAMIN        BL                                 C
400000000BENJAMIN        BL1054                             C
400000000BENJAMIN        BL      1074                       C
400000001BENJAMIN        BL           200                   C
500000000TATER           C                                  D
555555555NEW EMPLOYEE    RT1145                             C
555555555NEW EMPLOYEE    RT11440681100E644406813900006 81A
555555555NEW EMPLOYEE    RT                555              C
700000000JONES           A                          385000781C
800000000SMITH           BB                400              C
```

PROMOTION FILE:

Benjamin's salary will be updated in the new master

```
400000000BENJAMIN                 350000182        R
400000000BENJAMIN                          44 0182P
500000000TATER                    330000182        R
600000000GRAUER                            9990182P
900000000SMITH                    900000182        R
888888888JOHNSON                  400000182        R
```

OLD MASTER FILE:

```
100000000SUGRUE        P 12450879100E53330880222087928000108126000098O
200000000CRAWFORD      MA0943067810OE64440678          4200006803600006 78
300000000MILGROM       IR06130580200E65551081400068148000058O
400000000BENJAMIN      BL10531073100E73331073          3000010812800O1080
500000000TATER         JS02500779200P43330779          31000108127000O779
600000000GRAUER        RT11450877200E5900118180011805000011814500011 80
700000000JONES         A 09500778100G64440779333077839000088136000O779
800000000SMITH         BB08520681300P84440681          385000681
900000000BAKER         E 06490879100G99870879          65000088155000O879
```

OUTPUT FROM MODIFIED SEQUENTIAL UPDATE

NEW MASTER:

Benjamin now has 3 salary levels to indicate that a salary update has taken place

```
000000000BOROW          JS03431281100X99871281          550001281
100000000SUGRUE         P 124508791 00E533308802220879280001081260000980
200000000CRAWFORD       MA09430678100E64440678          420000680360000678
300000000MILGROM        IR06130580200E65551081400068148000 0580
400000000BENJAMIN       BL10541074100E744401823331073350000182300001081280001080
555555555NEW EMPLOYEE   RT11440681100E65550681          390000681
600000000GRAUER         RT11450877200E59990182900118150000118145000l180
700000000JONES          A 09500778100G64440779333077838500078136000 0779
800000000SMITH          BB08520681300P84000681          900000182385000681    0    0
900000000BAKER          E 06490879100G99870879          650000881550000879
```

DELETED RECORD FILE:

Deleted records are now written to a separate file

```
500000000TATER          JS02500779200P43330779          310001081270000779
```

ERROR MESSAGES:

Error message is better formatted

```
ERROR DUPLICATE ADDITION:
  TRANSACTION IN ERROR: 200000000CRAWFORD      MA09430678100E64440680420000680A

ERROR-NO MATCHING RECORD:
  TRANSACTION IN ERROR: 400000001BENJAMIN      BL          200                      C

ERROR-NO MATCHING RECORD:
  PROMOTION IN ERROR: 500000000TATER           330000182       R

ERROR-NO MATCHING RECORD:
  TRANSACTION IN ERROR: 555555555NEW EMPLOYEE  RT1145                               C

ERROR-NO MATCHING RECORD:
  PROMOTION IN ERROR: 888888888JOHNSON         400000182       R
```

THE POINT OF THIS EXERCISE IS THAT NON-TRIVIAL CHANGES CAN BE MADE TO EXISTING PROGRAMS, EASILY AND CORRECTLY.

THIS ASSUMES THAT THE PROGRAM WAS WELL DESIGNED AND CONSISTS OF HIGHLY COHESIVE, YET LOOSELY COUPLED PARAGRAPHS. ONE HAS A HIGH DEGREE OF CONFIDENCE THAT THE CHANGES WILL WORK, AND FURTHER, THAT A CHANGE IN ONE MODULE WILL NOT CREATE ADDITIONAL PROBLEMS.

THE IMPORTANCE OF COBOL COSMETICS IS NOT TO BE UNDERESTIMATED. THE CHANGES WERE FACILITATED, IN PART, BY THE AESTHETIC APPEAL OF THE COBOL PROGRAM. PROPER INDENTATION AND MEANINGFUL DATA NAMES ARE OF PARAMOUNT IMPORTANCE.

MAINTENANCE EXERCISE

Discuss the implementation of the following changes with respect to the expanded hierarchy chart; i.e., indicate what additional modules are required and/or which existing modules will change. Indicate how the changes will be made in the program itself.

1. Salary increases are no longer put through automatically, but are to be rejected if any of the following conditions occur:

    a. The transaction salary matches the present salary in the old master,

    b. The transaction salary date matches the present salary date in the old master,

    c. The performance code in the old master is P, and

    d. The name and initials on the transaction record do not match the name and initials on the old master.

2. A new transaction type, S, accommodates a change in social security number to an existing record. The existing (but incorrect) social security number is to appear in columns 1 through 9 of the transaction record, while the corrected social security number appears in columns 58-66. Realize that if a social security number is changed, the new master file will be out of sequence and must be sorted. However, sorting is not to take place if no social security numbers are changed. (If multiple transactions are included, all transactions should reference the old social security number.)

3. A new one-position numeric field is included at the end of the transaction record to permit historical corrections on title or salary data. Specifically, a 1 indicates the present level is to be corrected, a 2 the previous level, and so on. Valid values are 1, 2, and 3, since 3 levels of salary data are defined. Valid levels for a title correction are 1 and 2. (You may assume that the stand alone edit program has verified that the level is valid.)

4. Deletions now contain a date in the TR-TITLE-DATE field. The deleted record is to contain this date as its present title date, and the title code 999 as its present title. (This in turn causes the present title data from the old master to become the previous values in the deleted record.) Records deleted from the old master file are still to be written to DELETED-RECORD-FILE.

5. Promotions (i.e., title changes) are to be rejected if any of the following conditions occur:

   a. The transaction title matches the present title in the old master,

   b. The transaction title date matches the present title date in the old master, and

   c. The name and initials in the transaction record do not match the name and initials in the old master.

REFERENCE

1. The Balance Line Algorithm is described in an article by Dwyer, "One More Time - How to Update a Master File", Communications of the ACM, Volume 24, Number 1, January 1981.

2. The material in this presentation was extracted from a forthcoming book by R. Grauer, Structured Methods Through COBOL, to be published by Prentice Hall, and available in January 1983.

TEACHING SYSTEMS ANALYSIS AND DESIGN

Jeffrey L Whitten

Remarks

CIS-4, Systems Analysis Methods, and CIS-5, Structured Systems Analysis and Design, are the core systems development courses in the DPMA model curriculum. Professor Whitten will offer some of his insights on the implementation of these two courses. The course syllabi presented by the DPMA model curriculum will be viewed the minimum learning experience. Suggested supplemental learning outcomes will be offered. The course descriptions, student [minimum] outcomes, course content, and course approach has been previously detailed.[1]

Systems Analysis Methods, as the initial course, concentrates primarily on system documentation tools and techniques rather than the process of analysis and design (deferred until CIS-5). The course method suggests individual exercises or a comprehensive project (also individual). Professor Whitten will outline two alternative project approaches; one for the analysis of an existing system, the other for the design of a target system. The latter approach will be suggested as most appropriate for a stand-alone course in the community college or two-year subset of the curriculum. Professor Whitten will also address the need to provide stronger conceptual framework for the course and the need to integrate classical and structured methods rather than treating them as an either/or proposition.

Structured Systems Analysis and Design is the second of the two courses. Its emphasis is placed on problem solving skills, communications skills, and the methodology of systems development. Professor Whitten will suggest the need for an extended structured approach that more capably meets the need for methodologies that can support the development of decision support systems. Structured Analysis and Design are less effective in these instances when users cannot clearly express their requirements (data flows). A project approach will be suggested.

Finally, the need for understanding the "people" and "behavioral" aspects of analysis and design will be presented as the major inadequacy in CIS-4 and 5. While this topic can be stressed by the individual intructor in the classroom, it must be experienced to be fully appreciated. Professor Whitten will suggest and describe a

1 Adams, David R. and Thomas H. Athey, Editors, "DPMA Model Curriculum for Undergraduate Computer Information Systems Education", 1981, DPMA Education Foundation, pp. 30-35.

strong interface to the CIS-7 course (Applied Software Development Project) as one solution to the problem.

AUGMENTING THE MODEL CURRICULUM
ELECTIVE COURSES

DECISION SUPPORT SYSTEMS

SMALL BUSINESS COMPUTERS

EDP AUDIT AND CONTROLS

Chairman: John F. Schrage
Associate Professor, Management Systems & Sciences
Southern Illinois University at Edwardsville
Edwardsville, IL 62026

Members: Dorothy G. Dologite
Assistant Professor, Statistics and
Computer Information Systems
Baruch College
City University of New York
New York, NY 10010

Frederick Gallegos
Manager, Management Sciences Group
U.S. General Accounting Office
Los Angeles, CA 90071

ELECTIVE COURSE IN DPMA CURRICULUM

CIS-08 SOFTWARE AND HARDWARE CONCEPTS

CIS-09 OFFICE AUTOMATION

CIS-10 DECISION SUPPORT SYSTEMS

CIS-11 ADVANCED DATA BASE CONCEPTS

CIS-12 DISTRIBUTED DATA PROCESSING

CIS-13 EDP AUDIT AND CONTROLS

CIS-14 INFORMATION SYSTEMS PLANNING

CIS-15 INFORMATION RESOURCE MANAGEMENT

CIS-10 DECISION SUPPORT SYSTEMS

DESCRIPTION:

1. A study of the design, development, and implementation of the highest level of information systems which serves the management decision-maker (user).

2. This set of systems provides quantitative-based information derived from one or more data bases within and/or external to an organization and used to aid managers in the decision-making process.

3. Decision support systems (DSS) combine management information systems, management science, and organizational behavior concepts in the analysis and design of systems to support decision processes.

4. Theoretical concepts will be applied to real-world applications with an analysis of examples from specific organizations.

PREREQUISITE: CIS-1, Introduction to Computer-Based Systems.

COURSE CONTENT

topic	skill level
1. SYSTEMS AND INFORMATION CONCEPTS (10%)	2
2. STRUCTURE OF SYSTEMS IN RESPECT TO ORGANIZATIONS (10%)	2
3. TOOLS IN USING SYSTEMS (15%)	2
4. THE INFORMATION SYSTEM FOR MANAGEMENT (15%)	2
5. DECISION SUPPORT SYSTEMS (25%)	2
6. APPLICATION OF CONCEPTS WITH CASE STUDIES (15%)	3
7. COMMUNICATION SKILLS (10%)	3

::

COMPARISON WITH ACM CURRICULUM

CIS 10 DECISION SUPPORT SYSTEMS

also called Management Information Systems and/or Decision Support Systems during the preparation of the CIS Model DMPA Curriculum.

A C M Info Sys Curr

The CIS 10, Decision Support Systems course is a combination of the following ACM Information Systems Curriculum Courses:

IS 3 MANAGEMENT INFORMATION SYSTEMS IN ORGANIZATIONS

and

IS 7 DECISION SUPPORT AND MODELING SYSTEMS

A CIS-16 Course on Small Business Computers?

Dr. Dorothy G. Dologite
Baruch College - City University of New York

This paper proposes that a course on "Small Computers for Business" be considered for inclusion as a new "CIS-16 Elective Course" in the DPMA Model Curriculum.

It seems that the Model Curriculum is overwhelmingly mainframe oriented. This runs counter to current trends.

The problem could be rectified with at least a "CIS Elective Course" like CIS-16 Small Computers for Business. I have developed such a course for Baruch College of the City University of New York. The course description, outcomes, content, etc., has been cast into the format adopted by the DPMA to publish its Model Curriculum courses. It is attached for review and discussion is solicited.

The course is "applications" and "hands-on" oriented. It seems it would be one of the few courses, as the Model Curriculum is now structured, that would give students a computer experience from "power-on" to "power-off."

CIS-16 SMALL COMPUTERS FOR BUSINESS

COURSE DESCRIPTION

An intensive study of the application of small computers to solve business problems from single-server systems to those serving hundreds in a distributed data processing environment. Common heavily used applications on small computers, like word processing, financial worksheet planning and modeling, and stand-alone as well as integrated accounting, will be examined. Required lab projects include the design and programming of a small computer business application and the systematic evaluation of several software packages. Small computer system alternatives, selection, implementation and vendor commitments are examined. Prerequisite: CIS-5, Structured Systems Analysis and Design.

STUDENT OUTCOMES

To prepare students to be intelligent users and implementors of small computer business solutions. To be able to place today's small business system capabilities into perspective. To develop the ability to intelligently evaluate, buy and implement hardware and packaged software. To develop the ability to bring up an application from scratch on a small computer.

COURSE CONTENT

1. Characteristics of Small Computer Systems (5%) — Skill Level 2

   Basic components and design models. Features and differences among micro, mini and large scale computers. Spectrum of capabilities. Population of suppliers and users. Positives and negatives. Future trends.

2. Planning for Small Computers (5%) — Skill Level 2

   Hardware and software considerations and tradeoffs. Make-or-buy considerations. Single-user, multi-user, distributed data processing environments. Local networks and data communications.

3. Software and Hardware Acquisition Considerations (5%) — Skill Level 2

   Locating proprietary software using ICP Directory, trade magazines, and other information sources. Locating hardware using loose-leaf reference services, store demonstrations, vendor literature, etc. Vendor reliability and reputation. Multi-vendor arrangements. User interviews. Benchmark tests. Checklists. Evaluation matrix.

4. Evaluating and Implementing Application Packages (40%) — Skill Level 3

Determining specific user needs and implementing common application packages such as: word processing, electronic financial worksheet, stand-alone and integrated accounting, data base and file management, project management, portfolio management, financial modeling, graphics, and communication services systems. Evaluating specific commercial packages. Case problems. Successful and unsuccessful examples.

5. Original Application Analysis and Design Considerations (5%) — Skill Level 3

Review of software development life cycle. Adaptation to scale of user environment and system requirements. Problem definition. Structured analysis and design. Programmer training. Program development and testing. Performance validation. Audit and control considerations.

6. Analyzing and Designing a System (40%) — Skill Level 3

Actual case study problem analyzed, designed and implemented. General accounting or industry specific user areas.

EXERCISES AND PROJECT

Ideally this course will use packaged software for some student exercises minimally including a word processing. electronic financial worksheet, and stand-alone accounting or simple data base/file management packages. If "hands-on" software is not available, case studies could be used for this application orientation.

A term project should also be required which involves the program design and implementation of a simple billing or other application. Students can be expected to be prepared, from the CIS-5 prerequisite, to handle the analysis and design phase of the project without much difficulty.

A simple application is recommended because time is needed to learn how to use a new system. Learning how to create interactive user software from "power-on" to "power-off" is one of the positive values of the term project.

COURSE APPROACH

This course is primarily a "hands-on" course in which the student gains a working knowledge of what small computers are and how they fill common business application needs. It also gives students a valuable computer experience from "power-on" to "power-off."

Ideally, if time permits, in addition to the exercises and project detailed above, students should complete a hardware and/or packaged software search. This should be related to the term project. For example, if a medical billing system is designed and programmed, the software search should be for a comparable package. The hardware search could be for a system more powerful than that used.

SELECTED REFERENCES

While there are many books available on small computer systems for business, no single textbook directly addresses all the concerns of this course. Readings must be chosen from among the many selections available through books, publications and reference sources. This aspect of the course will need special attention since the area of small computers for business represents one of the most volatile areas of data processing.

Best, Peter J. Small Business Computer Systems. Prentice-Hall, 1980.

Brandon, Dick H. and Sidney Segelstein. Business Computers. Boardroom Books, 1981.

Datapro Directory of Small Business Computers. 3 vols. Datapro Research. Or other reference sources as appropriate.

Grillo, John P. and J. D. Robertson. Microcomputer Systems: An Applications Approach. William C. Brown, 1979.

ICP Directory - Mini-Small Business Systems. 2 vols. International Computer Programs, Inc. Or other software reference sources as appropriate.

Mini-Micro Systems and other trade publications as appropriate.

Shaw, Donald R. Your Small Business Computer. Van Nostrand, 1981.

Warren, Carl and Merl Miller. From the Counter to the Bottom Line. Dilithium Press, 1979.

Operating system, high-level programming language, and user application manuals as required.

Frederick Gallegos

CIS-13 EDP AUDIT AND CONTROLS

°Introduction to Fundamentals of EDP Auditing

- --EDP controls
- --Type of EDP audits
- --Concepts and techniques used in EDP audits
- --Exposure to risk assessment
- --Professional standards

STUDENT OUTCOMES

°Understanding of what EDP auditing is

°Importance of EDP controls and effect poor controls can have

°Appreciation of and motivation for proper data processing practices and management

COURSE CONTENT

Subject Area	Level of Skill
--EDP Audit Environment and Computer Information Systems (10%)	Skill level 3
--Information Systems Controls (25%)	Skill level 3
--Computer Audit Techniques (30%)	Skill level 2
--Auditing Adv. Information Systems (20%)	Skill level 2
--Systems Approach to Auditing (15%)	Skill level 3

PROJECTS

I. Research Paper on an EDP audit-related topic or a Test Data Case providing hard-on experience

II. Case Study

--Involving the use of

--audit retrieval language
--test data

--On-line case problem

TRACK IV

PROFESSIONAL DEVELOPMENT FOR BUSINESS

- The Information Systems Professional: Where Will He Go and How Will He Get There?
- Advantages of In-House Training Programs
- The Applied Software Development Project

INSTITUTE FOR CERTIFICATION OF COMPUTER PROFESSIONALS

35 EAST WACKER DRIVE [illegible]

[illegible]

THE INSTITUTE FOR CERTIFICATION OF COMPUTER PROFESSIONALS was founded in 1957 by the eight professional societies listed below.

PURPOSE

ICCP is a non-profit organization established for the purpose of testing and certifying knowledge and skills of computing personnel. It is a co-ordinated, cooperative, industry-wide effort.

A primary objective is the pooling of resources of constitutent societies so that the full attention of the information processing industry will be focused on the vital tasks of development and recognition of qualified personnel.

The Institute will foster, promote and encourage development and improvement of standards of performance and of good practice. It will become an authoritative source of information for employers, educators, practitioners and public officials.

PROGRAMS

ICCP serves as the focal point for its constituent societies which sponsor related programs so that the results of their activities may be incorporated into that of the Institute. In addition to testing and certification, ICCP planned programs include job definitions, curricula, continuing education, and self-assessment.

Examinations

The Institute currently provides the Certificate in Data Processing (CDP) and the Certificate in Computer Programming (CCP). One half day examinations are given annually at test centers in colleges and universities in the U.S.A., Canada and several other international locations for these certificates.

The CDP EXAMINATION consists of five sections which are intended to cover the broad range of knowledge important for the management of computing projects and organizations. The successful completion of all five sections, a minimum of five years computing work experience, and acceptance of the ICCP Codes of Ethics, Conduct and Good Practice are required to receive the Certificate. The attainment of the CDP is intended to certify the knowledge and understanding necessary to organize and direct the development of successful computing systems.

The CCP EXAMINATION is offered as three separate examinations. Each of the three examinations tests a common core of programming knowledge and an area of specialization. The three areas of specialization are Business Programming, Scientific Programming and Systems Programming. There is no specific experience requirement for the CCP but the candidate should be aware that the examinations are primarily intended for senior-level computer programmers. Successful completion of one of the examinations and acceptance of the ICCP Codes of Ethics, Conduct and Good Practice are required to receive the CCP in the area of specialization. Each of these certificates is intended to certify the knowledge and understanding necessary for the design and development of successful computing systems in that area of application.

Specific requirements of this year's CDP examination are detailed in the CDP Announcement and Study Guide available from ICCP headquarters.

Both the CDP and CCP examinations are administered by The Psychological Corporation, a New York-based research and testing organization.

STRUCTURE

The Institute is governed by a Board of Directors to which each constituent society designates two directors. The Board of Directors elect Officers of the Institute, who as an Executive Committee, act for the Board between meetings.

Standing committees that provide advice to the Board, and assist in the management of the Institute are:

(1) Program,
(2) Public Information, and
(3) Budget and Finance.

As programs are initiated by the Institute, Councils are established to oversee them and provide the necessary guidelines to assure the highest standards. Currently there are two Councils - the CDP Certification Council and the CCP Certification Council - which have jurisdiction over the CDP and CCP examination programs, respectively.

ACM: Association For Computing Machinery
ACPA: Association of Computer Programmers and Analysts
AEDS: Association For Educational Data Systems
AIA: Automation One Association
CIPS: Canadian Information Processing Society
DPMA: Data Processing Management Association
IEEE: The Computer Society of the Institute of Electrical and Electronic Engineers
SCDP: Society of Certified Data Processors

Enhancing Human Endeavor With the Use of Computers

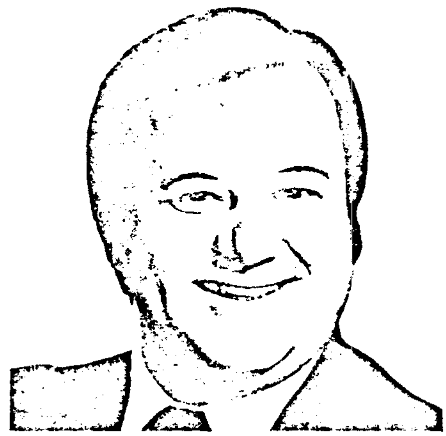
By Donald E. Price, President, Data Processing Management Assn.; Executive Vice President, Sierra College, Rocklin, Calif.

The information-management profession is moving at such a high rate of speed that traditional signposts are blurring. Just making the right moves and taking the right turns are becoming a risky operation demanding skill, knowledge and courage from information executives.

During 1982, the Data Processing Management Assn. will be totally committed to making the unknown a manageable and challenging territory for its members. In addition, DPMA will continue to play a key role in society's understanding of computers and what these tools can do for business, government, education and other sectors of human endeavor.

There is no doubt of the immense influence that computer and communications technology will have in the coming years. DPMA continues to provide members the ammunition so they are prepared to address targets such as lowered productivity, health care, economic modeling, safety of workers and thousands of other applications.

One area of the information cosmos in which the computer will be invading with light-year speed is the office. The speed with which this trend is moving can complicate introduction of electronics to the office. Our association is playing a significant role here by (1) educating its members to the complexities of office electronics, of the needs of top corporate management to the introduction of new systems and to the variety of systems and software available; (2) providing members and companies with advice, in the form of publications and national seminars, on how the office can go electronic in a systematic and integrated way.



". . . DPMA will continue to play a key role in society's understanding of computers and what these tools can do for business . . ."

With the popularity of computers, the chances of the information manager hiding behind his or her black box and computerese lingo are extremely slim. The computer manager has become quite visible: sometimes a target, sometimes a convenient place to lay blame, more often, fortunately, an opinion to be sought by other managers in the organization.

We are hard at work honing the skills needed for this new task—skills that include communications, persuasive influencing, negotiating, human-resource management and more. These skills were at one time the fenced-in domain of the MBA-trained executive, but no more. The power and spread of computers are leading to a broadening of the information manager's territory. Whether or not employers require that information managers have an MBA, the skills related to an MBA are certainly expected. In fact, this would probably be a losing battle if we simply concentrated on established information managers.

DPMA, through its Education Foundation, also is concerned about students being educated for careers in information management. Two months ago, the foundation released a precedent-setting Model Curriculum for Undergraduate Computer Information Systems Education. This is meant to improve the quality of graduates so business need not "retrain" someone who just spent four years and thousands of dollars getting ready for that information-processing position.

Another area of concern as the information manager becomes more visible is the issue of trust. With the public perceiving computers as repositories holding vast quantities of sensitive information on people, there is the desire to maintain the highest quality of computer professional who is charged with security of that information. We recently approved a Code of Ethics and Standards of Conduct that details ethical behavior by information managers who are members of the association.

In order to educate all sectors on the implications of the code, DPMA decided to hold off approval of an "enforcement procedure" for a short time, pending public review of the document and an understanding of the potential penalties for unethical behavior. The important point here is that a profession, in a healthy and high orbit, chooses to police itself in an effort to hold and enhance the positive confidence of computers by the public as well as business, government and education users.

We are just now breaking away from the confining gravity of a technologically weak atmosphere to the heady air of a sphere where computers and information systems allow people more time and resources to be more human. There is no more noble ambition. TO

DATA PROCESSING MANAGEMENT ASSN. was founded in 1952. Its annual conference is Oct. 17-20 in Chicago. Edward J. Palmer is executive director at 505 Busse Hwy., Park Ridge, Ill. 60068. (312) 825-8124.

THE ROLE OF THE DATA PROCESSING TRAINER

IN TURNOVER REDUCTION

TERRY H. EBERT, Ed.D.

Turnover continues to be a problem in data processing. There is every reason to expect this situation to continue.

Our industry has grown at a tremendous rate over the past several years. The U.S. Department of Labor reports the number of computer specialists, programmers, and systems analysts employed in the field increased from 607,000 in 1974 to 1,032,000 in 1979, which is a 70% increase. The industry was in excess of 300,000 people short of its needs when the year began in 1981. At that point, we were hiring an average of 930 people daily, and it has been estimated that by the year 2000 that number could exceed 2,700 people.

This growth can be seen even more clearly when you realize that by 1985 the DP industry will pull to within 17% of equalling the nation's mammoth auto industry and will probably pass it within the following year or two. Measured only in terms of value of hardware, if the current growth rate continues, by the mid-1990's it should be a $2 trillion industry. The number of people employed in the field, at that time, could exceed 5,000,000. Experience teaches us, that in a fast growing industry, trained people are hard to come by.

Recently, Computerworld reported the results of a survey which was sent to DP managers representing all areas of the country, all sizes of installations, and more than a dozen industries. Better than 60% of the respondents said that they were operating below their optimum staffing levels. The majority of the respondents said, additionally, that turnover had a "troublesome" effect on their overall DP operations.

The most recent turnover rate that I have seen is from 25 to 30%. This is from a group of some 245 companies selected according to a stratified random procedure and so seems to be accurate.

The costs of our "people problems", of turnover, are staggering. Consider the initial period of low productivity when you bring a new person onto a project, this is compounded by the effect upon the project of having to divert senior staff to train the new hire. Thus the low productivity spreads to more people. The direct costs of actually hiring a person are high. The staffing costs for a programmer hired at $25,000 (recruitment, selection, initial training) come to about half the annual salary. These costs, by the way, are quite a bit higher when we speak of analyst and managerial slots.

We also find that turnover has a multiplying effect within many organizations. Consider the effects upon the employees of an organization beset by high turnover - having to "double up on jobs," tightening up schedules, having vacations cancelled-in other words, working under added pressure. Will these people be content to continue in such a situation?

CAUSES OF TURNOVER

The growth of our industry is rapid and expected to remain so; the costs of turnover are great, both in a direct and indirect sense; it is important that we understand the major causes of turnover and how to handle each of these problem areas.

Salary is not as important a consideration as once thought. Several surveys have found that money is not a prime motivator in an employees's decision to job-hop. The three major factors have been found to be; (1) a lack of training, (2) a low degree of job satisfaction as it relates to career development, and (3) orgainzational climate as perceived by the programming staff. This paper will concern itself with the first two of these factors.

TRAINING

Let's discuss training, or the lack of training, in terms of it's relationship to turnover. In the survey that reported the number of DP organizations that were understaffed respondents were also asked what incentives were offered to retain people. A high percentage of those who reported below staff operations and difficulty in replacing those people lost to turnover,did not offer job related training programs.

One of the most common reasons cited at intake interviews for a programmers desire to switch jobs is a lack of state-of-the-art training or, just as important, the frustration of being given training that is neither timely nor appropriate in light of project assignments.

Employers are sometimes reduced to promising that new hires will work with on-line systems or will be trained in these systems. This can prove dangerous in two ways - it can affect the kinds of applications that get implemented (if the real need is to completely update an existing batch system, but people balk at working on the project, it's difficult to get the job done). On the other hand, if people are trained in a discipline such as CICS when they won't have any chance to work with it they become very frustrated. I know of situations where managers, faced with turnover problems, told their people that they'd get them CICS training even though there were no plans to use CICS at those shops for over a year. Well, the people happily accepted the training, went back to what they now considered an even more frustrating work environment, and then happily went off to a position where they could use their newly acquired skills. Training must be job related.

Research conducted by Daniel Couger highlights the importance of effective training for DP professionals. Couger found that programmers and programmer-analysts have the highest growth needs of any class of workers surveyed. High growth need reflects a strong desire for personal accomplishment, for learning and developing new skills, and for being stimulated and challenged.

A related survey administered to DP personnel in the New York City area illustrated the importance of in-house training as a tool for keeping programmers informed. More than fellow programmers, book/manuals, college courses, installation standards, and programming schools, in house training was cited as the main source of information on skill development and maintenance.

Current research indicates that DP progessionals strive constantly to improve their technical abilities. In one study, programmers were asked to rate 38 items in terms of professional need. The item identified as most important was the desire to be trained in a new operating system being planned in their installation. Items 7 through 10 on the scale were also related to technical training and were perceived as being more important than salary increases.

There are, therefore, six major points to keep in mind regarding training as a factor in turnover reduction:

- State of the art skills are important to our population.
- In-house training is the most important means that programmers have to maintain these skills.
- Training for its own sake is wasteful and can, in fact, increase turnover. Training must be timely and appropriate.
- Training can be used to develop a greater applications knowledge (and to increase organization loyalty).
- Training can, through cross training across sections and shifts, spread managements risk in case of turnover and offer backup to critical posts.
- And, last but not least, as Carol Oliver, manager of information control at Sun Life Services, says "If you don't train your people, they'll go to work for someone who will".

CAREER DEVELOPMENT

A second major factor in turnover reduction - one also related to the in-house training of DP professionals is job satisfaction and career development. Employment interviews frequently find that a major reason for seeking a job change is the feeling of "Not being able to go anywhere" - of being in a dead-end slot. Woodruff, found that many DP personnel feel locked into their present positions with little opportunity for advancement.

On the job, what do DPers want? According to a recent survey, junior members of DP staffs want challenging work with new systems that seem important. Senior members want assurance of career growth ahead, recognition for jobs well done and smooth relations with user departments. It has been found that a DP staff's morale can hinge upon these factors. In fact many managers have found that their staffs tend to worry more about promotions than salary raises.

This is brought home quite clearly by looking at the results of a study presented by Daniel Couger at a recent DPMA session. The five factors he found critical to motivation are skill variety, task identity, task significance, task autonomy, and feedback. The variety of skills necessary to hold a DP job seems to be a point of pride among many programmers. Most people, as well, have shown a demand to have jobs clearly defined - this is measured by the need for task identity. Task importance and task autonomy relate to the need to understand how one's individual effort contributes to the success of the organization. Couger again found that the growth need of DP professionals is very high and that this need is best met through promotion and the challenge of a new position.

As any supervisor who has interviewed propective employees knows, one of the first questions from a candidate is, "What is the career path for me in your company?" Some interviewers stumble along with some fabricated excuse that tries to hide the fact that the department has no career path. Others pull out an organizational chart and proudly point to themselves and imply that it is "normal" to receive promotions to management ranks.

A more realistic plan is to show professionals a career path based upon title and job responsibility changes. The path should be defined so that a programmer or analyst can see a promotion at least every two years - and sooner for the best performers. If a programming staff has not had significant title changes in the past two years (other than those caused by turnover), that department obviously does not have a career path.

Career paths for systems and applications programmers can, and should, contain at least three and preferably four ladders. These would lead to positions in applications programming, systems, management, and marketing.

There are special concerns to be aware of when an employee elects the management track of the career path.

The technician is concerned with doing things right. He is solution - oriented, tackles things from a limited scope, and expects immediate results from his efforts. He is generally primarily loyal to his profession.

The manager, on the other hand, is concerned with doing the right things. He has loyalty to the profession and (and this is a big and) to the corporation. Because he has as his responsibility a department of professionals, he must direct their energies to coincide with a broader set of corporate objectives. This requires an entirely different set of talents from those of his people. Although it is usually not necessary for him to actually program, you will usually find him doing just that eventually if you've promoted without guidance and training.

Some companies have depended upon the general corporate training department for all management training. In these companies, technical training is controlled internally by DP, but management training is the responsibility of personnel. DP personnel have special characteristics that need carefully tailored courses.

If the central training department is not responsive to the special needs, than the DP department needs to consider conducting its own supervisory training or going to a consulting group that specializes in DP training.

Any career development program involving regularly scheduled reviews (they should be semi-annual) is going to have an impact on the training department (and through it on turnover) because of the training requirements that should come from such reviews.

It is important to establish lateral lines of communication between DP and other groups in the organization. Too often, DP professionals tend to congregate in their own private world of bits and bytes. They loose track of the company as a whole. Frequent guest speakers can solve that problem very quickly. These briefings should include operators and data entry personnel, who usually feel even more isolated.

To further this end, users should be provided with some form of "Fundamentals of DP..." training. Such training will familiarize the user with the DP organization (should include a tour of the data center) and should also provide the user with a better sense of his responsibilities in the systems design process. We have provided this training for certain companies with excellent results. Users tend to come away with a much better understanding of the importance of DP and the DP staff has a better basis for interaction. Such reporting must, of course, be anonymous - individuals must never be identified or your credibility will suffer.

SUMMARIZATION

Turnover always effects an organization. It is expensive. Difficulty in retaining competent personnel is most frequently encountered in those shops who offer few meaningful incentives. Lack of education, challenge, and poor data processing management is enough to discourage the most dedicated of professionals.

Recruiting firms can seduce our people only when we have let them become ready for such seduction. Maintain a state-of-the-art training program, provide viable and appropriate career paths, and the turnover rate will drop. This will show the cost-effectiveness of in-house training.

APPENDIX

Employment Trends in Computer Occupations

U.S. Department of Labor
Bureau of Labor Statistics
October 1981

Bulletin 2101

Employment Trends in Computer Occupations

U.S. Department of Labor
Raymond J. Donovan, Secretary

Bureau of Labor Statistics
Janet L. Norwood, Commissioner
October 1981

Bulletin 2101

For sale by the Superintendent of Documents, U.S. Government Printing Office
Washington, D.C. 20402 - Price $3.50

Preface

This bulletin presents the results of a Bureau of Labor Statistics study of employment of workers in five computer-related occupations. It includes information on education and training for computer occupations, the impact of advancing technology on employment and education, and projected employment requirements through the 1980's. The study was conducted as part of the Bureau's program to provide information about occupations for use in career counseling and education planning.

The bulletin was prepared in the Division of Occupational Outlook under the direction of Michael Pilot. Patrick Wash supervised its preparation. H. Philip Howard and Debra E. Rothstein conducted the research, analyzed the data, and wrote the report. Vidella H. Hubbard prepared the manuscript. The Bureau is grateful to the many individuals who provided information for the study and who reviewed and commented on the draft report.

Contents

Contents—Continued

Highlights

The use of computers has become widespread in our society.

- The number of computer systems has risen dramatically in the last decade. In 1980, more than 600,000 computer systems were in use, compared with only about 100,000 in 1970. The number is expected to continue to increase rapidly through the 1980's.
- At first limited to only a few industry applications, computers are now used in many industries. New applications are expected in the years ahead as rapid access to information becomes increasingly important.

The computer occupations are expected to be the most rapidly growing in the economy over the next decade.

- Employment in computer occupations is expected to rise from 1,455,000 in 1980 to 2,140,000 in 1990, an increase of 47 percent (chart 1). This is nearly three times as fast as the expected rate of growth for all occupations in the economy.
- Systems analysts are expected to increase from 243,000 to 400,000, or by 65 percent.
- Programmers are expected to increase from 341,000 to 500,000, or by 47 percent.
- Computer and peripheral equipment operators are expected to increase from 522,000 to 850,000, or by 63 percent.
- Keypunch operators are expected to decline from 266,000 to 230,000, a decrease of 14 percent.
- Computer service technicians are expected to increase from 83,000 to 160,000, or by 93 percent.

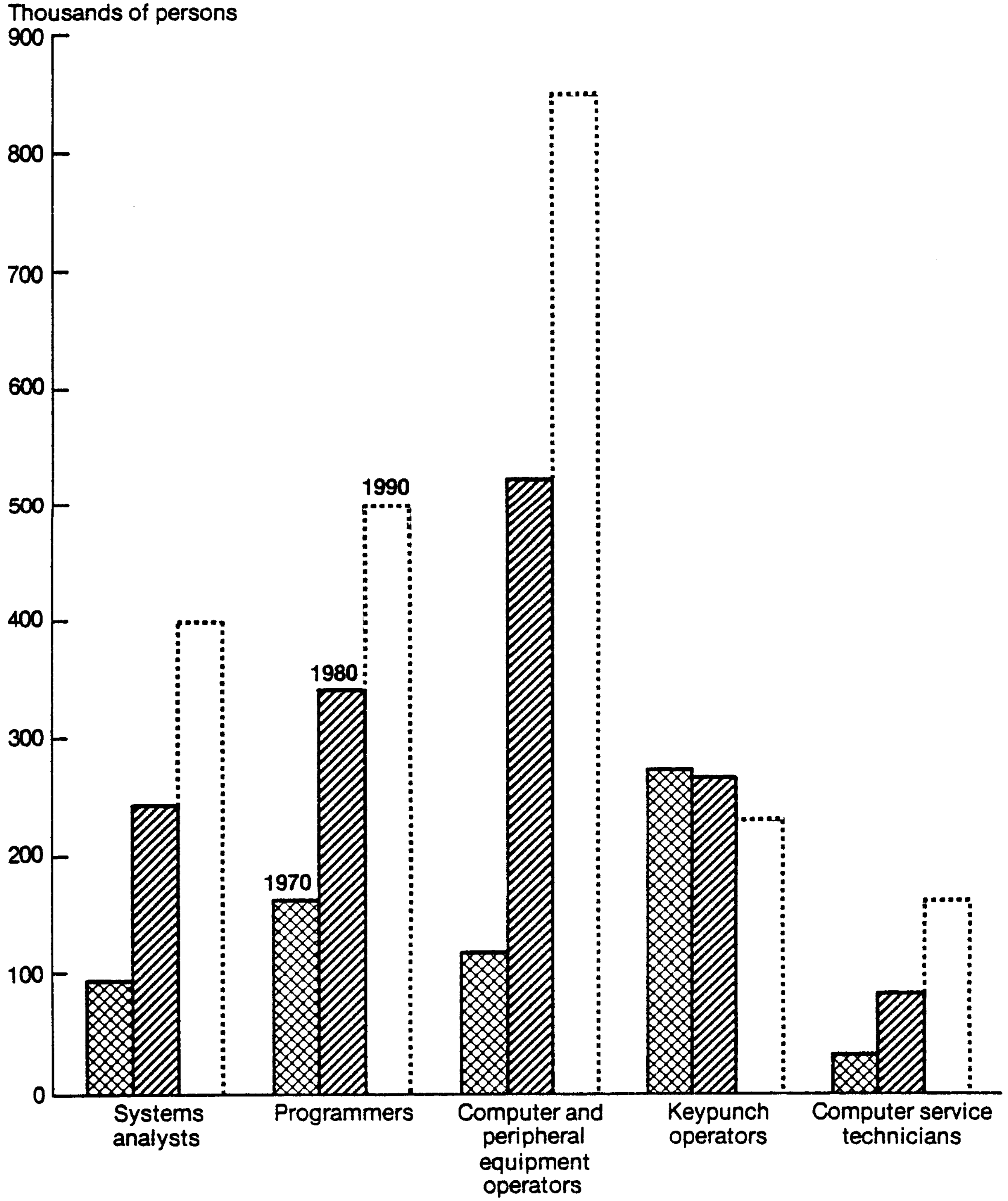
The increasing sophistication and complexity of computer operations will require workers with more and better training.

- Education and training for computer occupations have not kept up with needs.
- If future needs for trained computer personnel are to be met, major improvements are required in at least two areas— attracting qualified teachers and standardizing program content.
- Despite current shortcomings in education and training, improvements have been made. The number of computer degree programs is increasing rapidly, and there is a strong trend toward infusing computer training into curricula besides computer science.

Advances in all major areas of computer technology will supply the user with more computer capability per investment dollar.

- Hardware—Advances in microprocessor technology have stimulated the development of smaller, more efficient, and less costly computer equipment. Newer hardware is expected to have a significant impact on computer employment.
- Software—The development of easier-to-use programming languages and packaged programs is expected to continue. These developments, along with the trend toward incorporating systems programming functions into hardware, will permit more direct interaction between the user and the computer, and in some cases may simplify programmer job duties.
- Applications—The number of applications made practical by hardware and software advances will make the computer accessible to more users. This increased use due to new applications will be the most significant factor causing rapid growth in computer employment over the next decade.

Chart 1. Employment in computer occupations, 1970, 1980, and projected 1990



Source: Bureau of Labor Statistics.

Chapter 1. Employment

This study discusses employment in five computer occupations: Systems analysts, programmers, computer and peripheral equipment operators, keypunch operators, and computer service technicians.[1] Although a wide variety of other workers, from engineers to sales clerks, routinely use the computer in their daily tasks, this report focuses only on those occupations whose very existence depends on computers. Table 1 presents a brief description of the major job duties for each of the occupations studied.

In 1980, 1,455,000 persons worked in computer occupations. Two out of five worked with computer software, either in systems analysis or programming. Nearly 1 in 5 entered data as a keypunch operator while 1 in 20 maintained and repaired computer hardware. By far the largest single occupation was computer and peripheral equipment operator, which accounted for more than 1 of every 3 computer workers in 1980 (table 2).

Geographic distribution

Employment in computer occupations is concentrated in the major urban centers where the majority of companies owning general-purpose computer systems are located. The 25 metropolitan areas with the largest concentrations of general-purpose computers accounted for about 56 percent of the total value of these systems in 1978, and the top 100 metropolitan areas constituted 84 percent of this total.

However, as the use of minicomputers increases and as distributed data processing (DDP) networks become more widespread, computer systems will become less concentrated. This trend is expected to result in increased opportunities for computer employment outside metropolitan areas.

Industries of concentration

Although computer workers are found throughout the economy, 8 of every 10 are in four major industry divisions (chart 2).[2] In 1978, the greatest concentration, about 30 percent, was in the services division—primarily in computer programming services, colleges and universities, and accounting and auditing services. The second largest concentration, about 28 percent, was in manufacturing, predominantly in firms manufacturing durable goods. About 13 percent of all computer workers were in finance, insurance, and real estate, the great majority of whom worked in banks and insurance companies—organizations that have become heavily computerized in order to handle the large volume of transactions. Another 12 percent of all persons in computer occupations worked in wholesale and retail trade establishments. Most of these were concentrated in wholesale trade, where firms generally are large and where computers have been used for years for inventory and distribution functions.

The remaining five major industry divisions accounted for less than 20 percent of computer employment in 1978. Transportation, communications, public utilities, and government employed most of these workers; only 2 percent of all computer workers were found in mining, construction, or agriculture, forestry, and fisheries.

Industry trends, 1970-78

Employment of computer workers increased dramatically over the 1970-78 period, about two and one-half times as fast as the rate of growth of employment for the economy as a whole (chart 3). Computer employment grew rapidly in all industries, even in those that experienced little or no overall employment growth in the 1970's. In manufacturing, for example, total employment rose only 5 percent between 1970 and 1978, but computer employment rose 34 percent.

The growth of computer occupations is unlike the usual pattern of occupational growth whereby employment increases as a result of growth in the industries in which the occupations are concentrated. Employment of secretaries, for example, has grown rapidly in recent years, due in large part to the rapid growth of the

[1] Fifty-five different occupational titles, shown in appendix C, were subsumed by the Bureau of the Census in the 1970 Census and in the Current Population Survey from 1971 to 1980 under six occupational categories: Computer programmer, computer systems analyst, computer specialist not elsewhere classified, computer and peripheral equipment operator, keypunch operator, and data processing machine repairer. The BLS 1970 industry-occupational matrix paralleled the Census classifications. This study, however, combines two of these classifications, systems analyst and computer specialist not elsewhere classified, because of the similiarity of the work. This study also uses the term "computer service technician" in place of the Census title "data processing machine repairer" in order to better reflect the job duties these workers perform.

[2] Data on the industry division of computer workers are based on the 1978 industry-occupational matrix, the most current matrix available when this study was prepared.

Table 1. Description of duties of computer workers

Occupation	Duties
Systems analysts	Analyze business, scientific, and engineering problems for application to electronic data processing systems. These workers are classified according to their specialty. *In business*, they analyze business procedures and problems such as development of integrated production, inventory control, and cost analysis systems, to refine data and convert them to programmable form for electronic data processing. *In scientific and technical areas*, they perform logical analyses of scientific, engineering, and other technical problems, and formulate mathematical models of these problems for computer solution. *Systems engineers* analyze electronic data processing projects to determine equipment requirements. After determining equipment requirements, they may plan the layout and implementation of computer systems to achieve efficient operation.
Computer programmers	Convert business, scientific, and engineering problems to logical flow charts for coding into computer language. These workers are classified according to their specialty. They analyze all or part of a workflow chart or diagram to develop a sequence of program steps. To do this, programmers must apply their knowledge of computer capabilities, subject matter, mathematics, and symbolic logic. They then convert the steps to language that can be processed by the computer.
Computer and peripheral equipment operators	*Computer (console) operators* monitor and operate the control console of a computer to process data according to operating instructions. They set control switches on the equipment, select and load the input and output units with materials—such as tapes and printout forms—and then clear the system and start the equipment. During the run, they observe the machines and control panel for error signals. *Peripheral equipment operators* operate on-line or off-line peripheral machines, according to instructions, to transfer data from one form to another, print output, and read data into and out of the computer.
Keypunch operators	Operate alphabetic and numeric keypunch machines to transcribe data from source material onto punchcards, paper or magnetic tape, or cards.
Computer service technicians	Install, repair, and periodically service computer equipment, following blueprints and manufacturers' specifications. These workers test faulty equipment and apply their knowledge of electronics to diagnose defects. They replace or repair defective components. On occasion, they consult with customers when planning the layout for installation or in diagnosing system malfunctions.

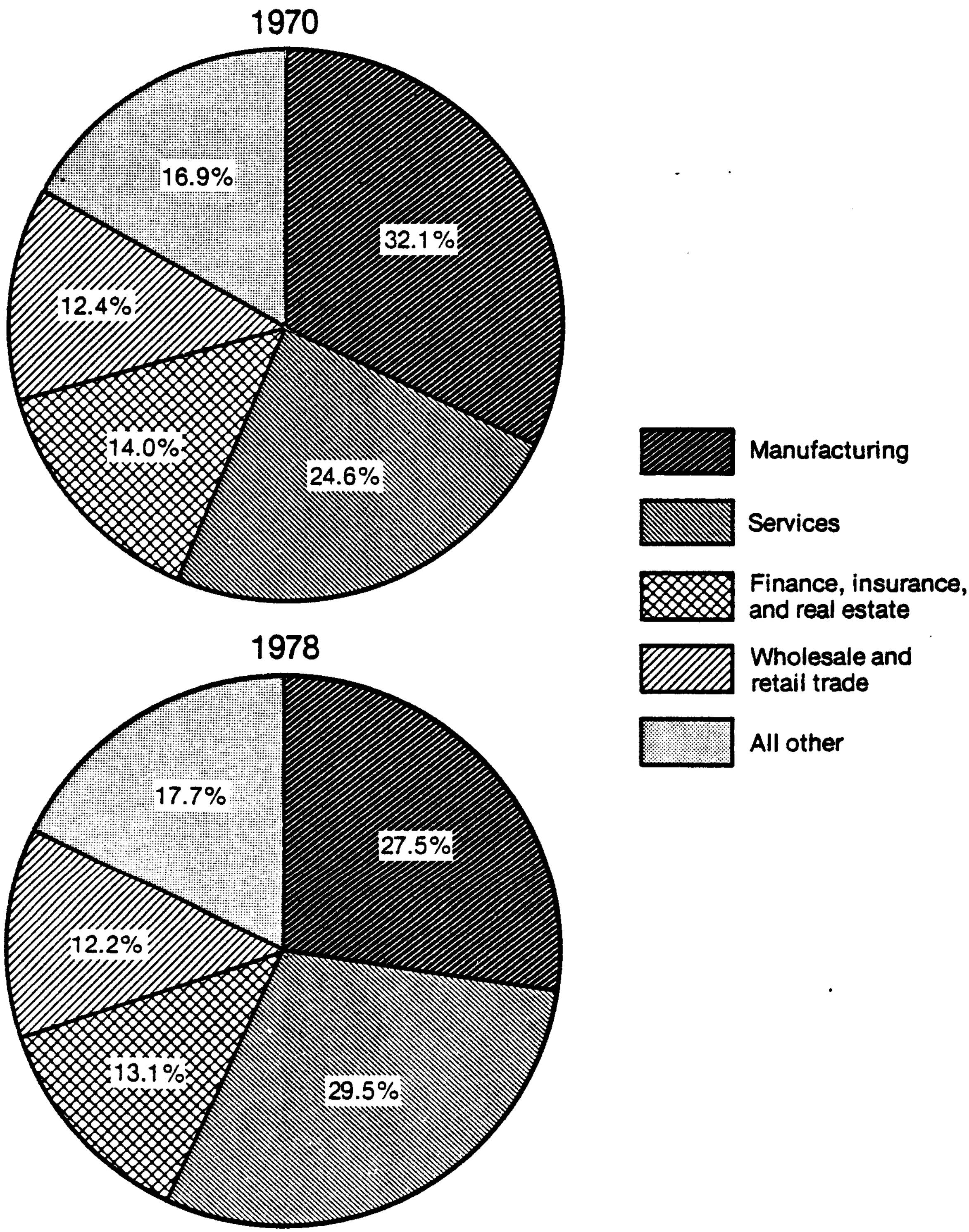
Source: Bureau of Labor Statistics.

Table 2. Employment in computer occupations, 1970-80

Year	Total	Systems analysts	Programmers	Computer and peripheral equipment operators	Keypunch operators	Computer service technicians
1970	676,037	93,200	161,337	117,222	272,570	31,708
1971	709,000	75,000	158,000	156,000	290,000	30,000
1972	798,000	88,000	186,000	196,000	283,000	45,000
1973	803,000	100,000	187,000	216,000	253,000	47,000
1974	857,000	113,000	199,000	246,000	249,000	50,000
1975	965,000	140,000	223,000	295,000	250,000	57,000
1976	1,000,000	158,000	229,000	287,000	276,000	50,000
1977	1,003,000	150,000	221,000	302,000	280,000	50,000
1978	1,158,000	182,000	247,000	393,000	273,000	63,000
1979	1,352,000	213,000	321,000	453,000	274,000	91,000
1980	1,455,000	243,000	341,000	522,000	266,000	83,000

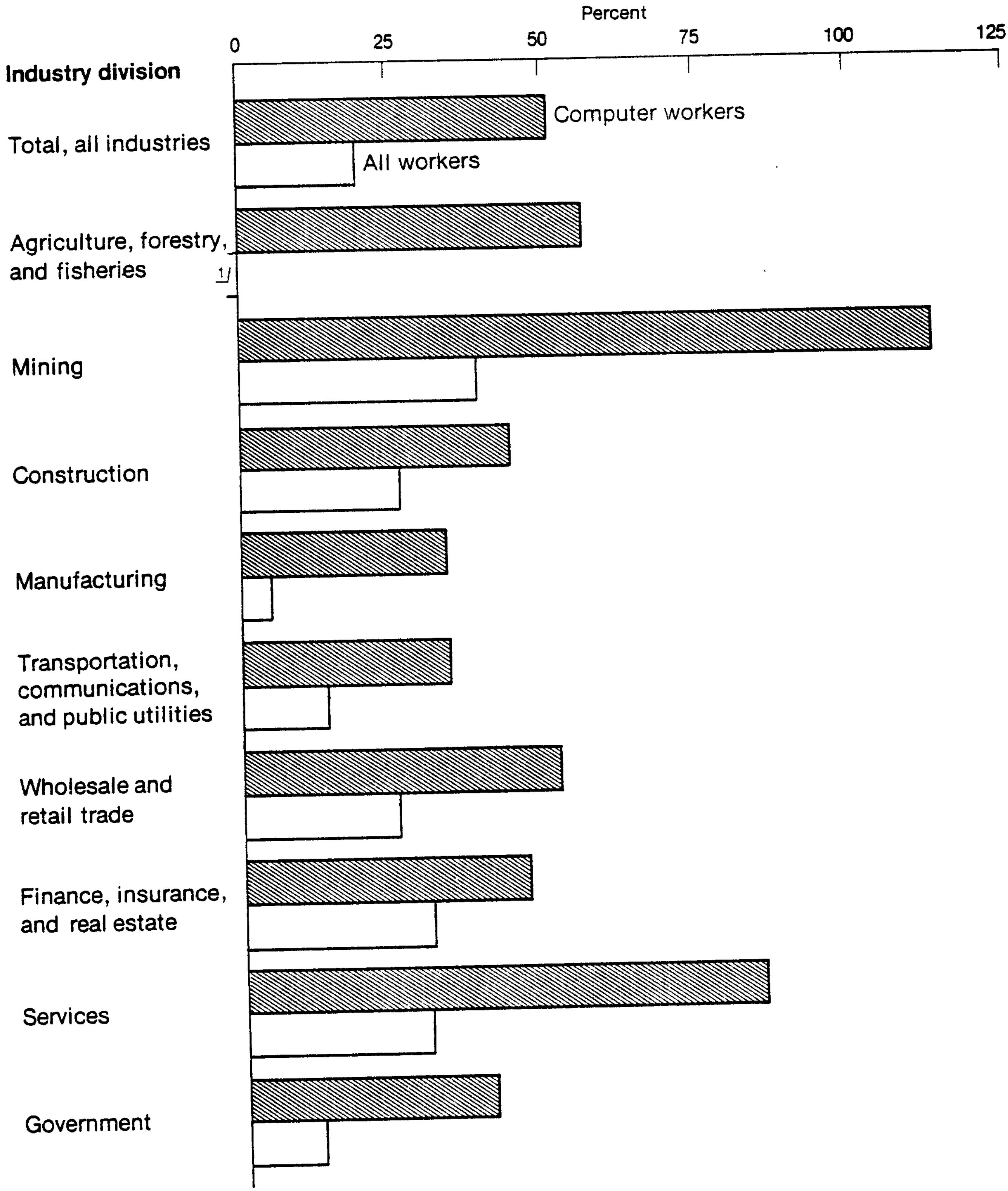
SOURCE: Bureau of Labor Statistics.

Chart 2. Employment of computer workers by industry division, 1970 and 1978



Source: Bureau of Labor Statistics.

Chart 3. Percent change in employment of computer workers and all workers by industry division, 1970-78



1/ Decrease of less than 0.05 percent.

Source: Bureau of Labor Statistics.

finance, insurance, and real estate sector and the services sector, which together employ almost one-half of all secretaries. As output of firms in these sectors expanded, more secretaries were needed to handle the greater number of support functions. Employment of computer workers, however, reflects an industry's capital expenditures for technology as employers install computers to increase efficiency and productivity, whether or not their output is expanding.

Not all industry sectors have computerized their operations at the same pace. These investment decisions are based on price and the adaptability of computer hardware and software to the needs of potential users. Prior to 1970, computers were generally limited to organizations whose size would justify the cost of a central mainframe. Many manufacturing firms, banks and insurance companies, wholesalers and large retailers, and colleges and universities maintained their own computer for batch processing of personnel records, payroll, inventory, and records of student enrollment, to list just a few standard applications. In addition, process control computers were applied to industrial processes that already had a high degree of control, such as steelmaking, petroleum refining, chemical production, and electric power generation. Organizations that could not afford to operate their own computer systems contracted with computer services firms to meet their data processing needs. Many others stayed completely out of the computer market.

Technological advances during the 1970's presented potential users with an array of more efficient and more flexible hardware and software at steadily falling prices that made it cost effective for a growing number of organizations to install a computer. More affordable mainframes, highly efficient minicomputers, small business computers, and a greater variety of software packages all contributed to the explosion in computer employment during the 1970's.

As previously noted, employment of computer workers in manufacturing firms grew almost seven times as fast as overall industry employment as smaller manufacturers installed less expensive mainframes and many others adapted computers directly to the production process. One technique that developed over the period was the utilization of minicomputers in distributed data processing networks throughout a plant to enable workers to better control operations such as the flow of raw materials and the precision measurement of manufactured items.

Computer employment in the services sector grew almost three times as fast as total industry employment as computer equipment became more affordable. Employment of computer workers grew rapidly in the types of establishments that already were computerized by the beginning of the decade—colleges and universities as well as firms providing accounting, auditing, and computer programming services. Even more rapid employment growth occurred in hospitals and other health services and in miscellaneous business services. Computer employment in health services increased as more flexible computer systems were increasingly adapted to medical diagnosis and patient care. Firms providing business management services, those doing commercial research and development, and private employment agencies were three of the more significant sources of growth in computer employment during the 1970's. These and other types of relatively small service firms were able to successfully incorporate small business computers into their operation.

Computer employment in wholesale and retail trade grew more than twice as fast as total industry employment as wholesalers installed distributed data processing networks to give themselves better control over their inventory and distribution functions. Employment in retail firms increased even faster as single-store operations installed a small business computer to handle their inventory and other business records and retail chains installed point-of-sale terminals linked to a central computer. Finance, insurance, and real estate experienced relatively moderate gains in computer employment between 1970 and 1978. This reflected the relatively slow growth of the insurance industry, which accounts for about one-third of total employment in this industry division, and the fact that operations in the insurance industry already had been largely computerized prior to 1970. This left only modest gains to be made in the 1970's.

Computer employment in government grew more than twice as fast as total government employment throughout the 1970's. This reflected the slower than average growth in government during this period, and the increasing use of computers to manage the enormous amount of recordkeeping that government programs require. Growth of computer occupations was strongest in State and local governments, where government employment growth was concentrated.

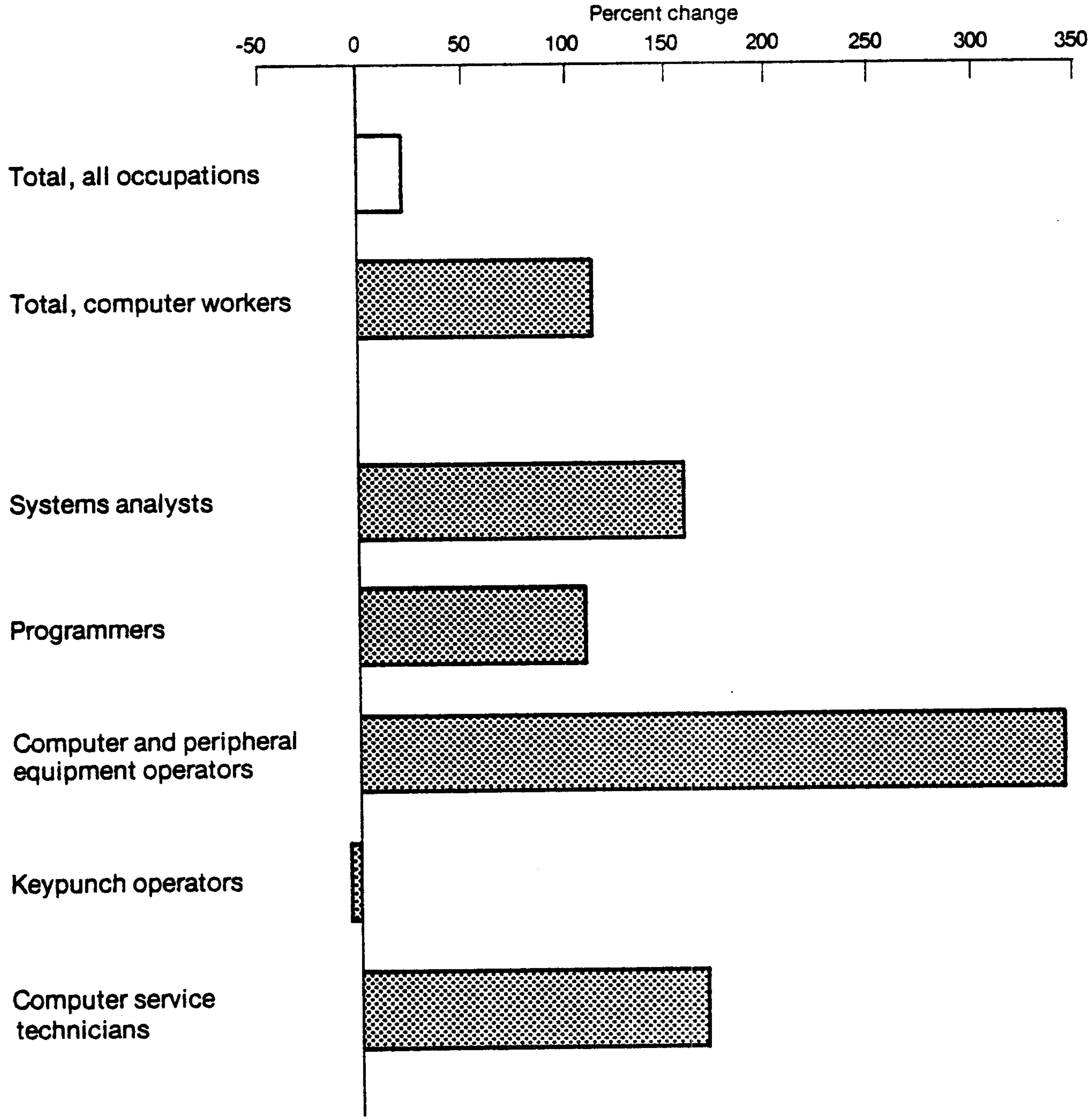
The smallest increase in computer employment occurred in transportation, communications, and public utilities. These are large, centralized industries that could afford the larger, more expensive computer systems available prior to 1970. It should be noted, however, that even this relatively modest increase exceeded the average growth rate for all occupations.

Computer employment in agriculture, forestry, and fisheries; mining; and construction combined increased faster than in any other sectors as the relatively small firms in these industries made substantial use of smaller, less expensive computer systems.

Occupational trends, 1970-80

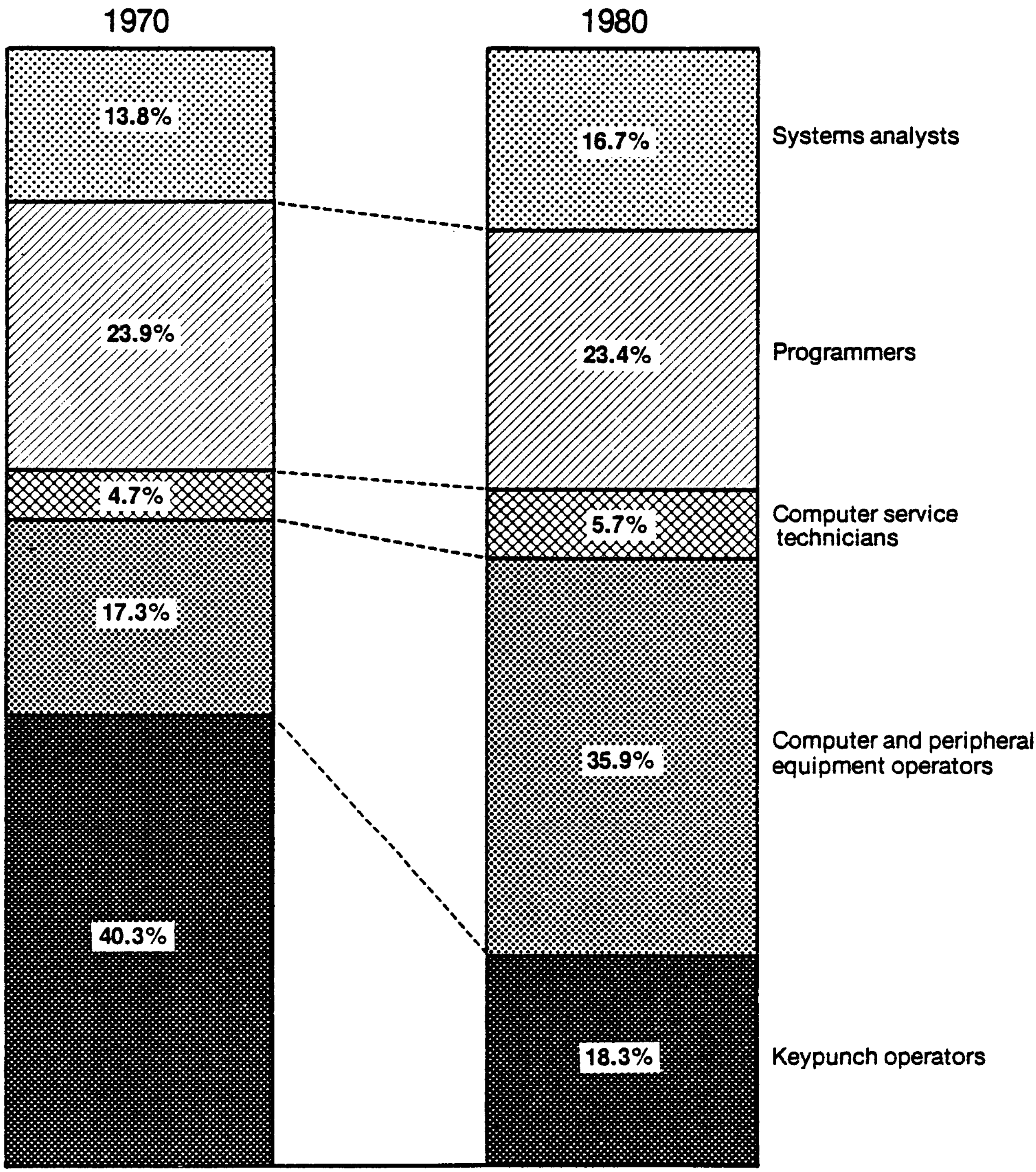
Employment of computer workers more than doubled between 1970 and 1980, growing from 676,000 in

Chart 4. Percent change in employment of computer workers by occupation, 1970-80



Source: Bureau of Labor Statistics.

Chart 5. Distribution of computer workers by occupation, 1970 and 1980



Source: Bureau of Labor Statistics.

1970 to 1,455,000 in 1980. This was nearly five times the average rate of growth for all occupations in the economy.

Technological advances and changes in methods of operation have resulted in vastly different rates of growth among the individual computer occupations (chart 4). All of the computer occupations except keypunch operators grew much faster than the average for all occupations. Programmer employment, for example, increased by about 111 percent, and employment of systems analysts increased by 161 percent, as industries in all sectors sought to develop and refine software for an increasing number of applications. Decreasing hardware costs and the resultant rise in the amount of computer equipment in use contributed to a 162-percent increase in the number of computer service technicians. The largest increase, however, was for computer and peripheral equipment operators, whose employment grew three and one-half times in response to the rapid increase in the number of computer systems in use. Employment of keypunch operators declined 2 percent as more efficient forms of data entry were developed.

The differing rates of growth experienced by the individual computer occupations signficantly changed the distribution of computer employment by 1980 (chart 5). Keypunch operator, for example, was the largest computer occupation in 1970, with about two-fifths of total computer employment. As technological innovations made their functions less important, their proportion of employment fell to less than one-fifth in 1980. By contrast, computer and peripheral equipment operators—who constituted less than one-fifth of computer employment in 1970—grew to become the largest of these occupations in 1980, representing over one-third of all computer personnel.

Chapter 2. Education and Training

Current requirements

Educational requirements for computer workers range from high school to a college degree and beyond. The most professional computer work, which involves systems design and analysis and systems programming, generally is done by persons having 4 years or more of college training. The middle range of computer work, involving scientific and complex business applications programming as well as equipment maintenance, is typically performed by those with training from a 2- or 4-year college or from a program operated by a computer vendor. The work requiring the least formal education involves basic applications programming, equipment operation, and keying functions. This work is usually carried out by high school graduates, many of whom have received some formal training from a public or private school or on-the-job training from a computer manufacturer or other source.

Regardless of educational level, however, the most desirable qualifications for programming and systems personnel are a background in computer science and data-processing-related subjects and a knowledge of the business the computer operation is serving. Educational requirements for the individual computer occupations are as follows:

Systems analysts. A bachelor's degree—including courses in computer science—generally is the minimum educational requirement. However, the type of degree employers prefer depends on the type of work done in the organization. For a job with a bank, insurance company, or business firm, a college degree in accounting, business, economics, or information systems is appropriate. For work in a scientific or technical organization, applicants need a degree in the physical sciences, mathematics, engineering, or computer science. In addition to the bachelor's degree in a suitable field, some employers prefer applicants to have related work experience.

Some employers require systems analysts to have a graduate degree. A growing number of employers seek applicants who have a degree in computer science or information systems. Regardless of college major, most employers look for people who are familiar with programming languages. Courses in computer concepts, systems analysis, and data base management systems offer good preparation for a job in this field.

In addition, most employers prefer applicants who have some experience in computer programming. Because of the importance of programming experience, many who begin as programmers are promoted to analyst trainees. Employers, computer manufacturers, and colleges and universities offer formal training in systems analysis.

Because technological advances occur so rapidly in the computer field, continuous study is required to keep skills up to date. Usually employers and "software" vendors offer 1- and 2-week courses. Additional training may come from professional development seminars offered by professional computing societies.

An indication of experience and professional competence is the Certificate in Data Processing (CDP), conferred by the Institute for Certification of Computer Professionals upon candidates who have completed 5 years' experience and passed a 5-part examination.

Programmers. There are no universal training requirements for programmers because employers' needs vary. Most programmers are college graduates; others have taken courses in programming to supplement their experience. Firms that use computers for scientific or engineering applications usually require programmers to have a bachelor's degree with a major in computer science and a minor in a physical science. Some of these jobs require a graduate degree. Although some employers who use computers for business applications do not require a college degree, they prefer applicants who have had courses in data processing, accounting, and business administration.

Public and private vocational schools, community and junior colleges, and universities teach computer programming and data processing. Instruction ranges from introductory courses to advanced courses at the graduate level. High schools in many parts of the country also offer courses in computer programming.

An indication of experience and professional competence at the senior programmer level is the Certificate in Computer Programming (CCP), conferred by the Institute for Certification of Computer Professionals upon candidates who have passed a 5-part examination.

Computer service technicians. Employers usually require applicants to have 1 to 2 years of post-high school training in basic electronics or electrical engineering from a computer school, technical institute, junior college, or 4-year college. A few technicians are trained through apprenticeship programs. Electronics training in the Armed Forces also is excellent preparation. Generally, 6 months to 2 years of on-the-job experience are required before newly hired technicians are considered competent to work independently on more complex systems. High school courses in mathematics, chemistry, and physics are considered good preparation. Communication skills also are important.

Computer operating personnel. High school graduation is the minimum educational requirement for computer operating jobs such as keypunch operator, auxiliary equipment operator, and console operator. Many employers prefer console operators who have some community or junior college education. Beginners usually are trained on the job; the length of training varies. Auxiliary equipment operators can learn their jobs in a few weeks, but console operators require several months of training before they are sufficiently familiar with the equipment to be able to trace the causes of breakdowns.

Formal computer training is desirable because most employers look for applicants who already are skilled in operating data entry equipment or computer consoles. High schools, vocational schools, computer and business schools, and community and junior colleges offer this type of computer training. Computer vendors also offer structured training programs for many of these workers.

Post-employment training

With the rapid changes in computer equipment and technology, there is a great need for continuing education programs for computer personnel. The extent of job-related supplementary training varies widely. Some employers have regularly scheduled, in-depth training programs in areas such as computer languages or data processing operations. Others provide this type of training only when changes are made in computer procedures or equipment. Many companies also maintain a tuition refund plan or pay for employee attendance at professional seminars. Regardless of the type or length of training, it is usually paid for by the employer.

The most common types of supplementary training include computer vendors' course offerings, in-house training programs, on-the-job training, professional seminars, and reimbursement for college, correspondence, and vocational school courses. The length of post-employment training ranges from a few hours to more than 1 year, but training usually is completed in 1 to 12 weeks—with the higher level computer jobs generally requiring the more lengthy training.

Among computer occupations, systems analysts most frequently take computer science courses as well as systems, programming, and management training. Programmers usually train in programming languages and techniques and, to a lesser extent, in systems analysis and design. Training for computer service technicians often involves computer electronics and related courses. Console, peripheral equipment, and keypunch operators train in data preparation, production control, computer equipment operation techniques and, occasionally, programming.

Current status of education and training

As described in the previous sections, various types of computer education and training currently are available. Because of the relative newness of the computer occupations and the shortage of skilled computer workers, however, some problems exist in training computer personnel.

One major problem that has persisted from the beginning of the computer era is a shortage of qualified teachers in this field. Educational institutions find it very difficult to keep their experienced teachers or to attract qualified teachers because salaries and research facilities often are not comparable with those offered by private industry. Many institutions are unable to offer more computer science courses because there are not enough instructors.

As a result of the shortage of qualified teachers and programs, the number of people receiving college degrees in computer science, although rising rapidly, is falling short of employers' needs. Graduates of programs in computer science are only filling 1 out of 4 jobs at the bachelor's level, 1 out of 10 jobs at the master's level, and 1 out of 4 jobs at the doctorate level.[3]

Due to the unique nature of the computer field—technological advances and applications are increasing at a very rapid rate—educational institutions find it difficult to design and implement courses that disseminate the latest developments in a timely manner. Thus, the subject matter in similar course offerings from different schools is not always consistent.

Despite the shortcomings of computer education and training in its current form, a number of positive developments have occurred in the past few years.

One development in computer education is the trend toward infusing computer training at the college and university level into other curricula besides computer science. For example, most schools now offer computer courses in their business and engineering programs. Furthermore, one college administrator has estimated that 1 out of 3 undergraduates and 1 out of 2 graduates now use a computer in their coursework.

In order to make programs more relevant and to

[3] John W. Hamblen, *Computer Manpower—Supply and Demand—by States, 1981* (Information Systems Consultants).

encourage consistency among computer curricula, the Association for Computing Machinery has issued revised recommendations for computer education programs. These guidelines include detailed course descriptions as well as recommendations on program organization and implementation.

Steps also have been taken by colleges and universities to meet the needs of those already in the labor force. Many schools now offer night courses in computer science, most of which are tailored to meet specific job requirements.

Computer vendors and others have refined their "canned" learning programs to meet employers' needs. These courses now cover a variety of computer concepts and practical applications. The programs, which utilize a number of learning techniques, are especially useful for occupations with high turnover because they are self-paced and relatively inexpensive.

As the computer becomes more prevalent in all aspects of our economy, it is increasingly important for people to become familiar with this tool. Towards this end, a growing number of high schools are offering computer education courses. These provide the student with some programming knowledge as well as an understanding of the logic of computing, and are excellent preparation for use of the computer in any career.

In summary, educating and training enough computer personnel to meet employer's needs still present a number of problems. The relative newness of the field, its rapidly changing technology, and the inability of educational institutions to compete for skilled teachers have all been contributing factors to the shortage of qualified computer workers in computer occupations. For a better understanding of the current situation, a brief look at the evolution of computer education and training is provided below.

Evolution of education and training

The dramatic rise in computer use during the 1950's outstripped the availability of personnel with data processing skills. As opportunities in the computer field expanded rapidly and the demand for skilled computer workers increased, many people sought training in this field. But schools were not yet providing courses in data processing. The educational system, of course, required a certain amount of time to develop programs to meet the specific needs of employers. Additionally, the implementation of educational programs was delayed by two factors. First, computers were needed to provide practical experience for the student, and this equipment was prohibitively expensive during the 1950's. Secondly, the relatively few people who were qualified to teach at that time could earn considerably more money in the business world.

As equipment costs gradually declined and as more instructors became available through the 1950's and 1960's, a growing number of public and private colleges, universities, and vocational schools began to include data processing in their curriculums. Nevertheless, the number of graduates with specific training for computer jobs continued to fall further behind the rapidly growing demand. To fill this widening gap, a large number of private vocational schools were established that offered computer training. Some of these schools, however, were criticized for providing poorly qualified teachers, limited subject matter, and obsolete computing equipment.

Thus, the major sources of training in the 1950's and 1960's became the computer manufacturers. Many persons trained in this way acquired only limited skills because their training usually focused on the operating procedures for their company's computer system. Employees trained in this manner, therefore, found it difficult to transfer or advance to jobs requiring knowledge of different types of computers and related equipment.

Computer manufacturers continued to provide training as part of the overall computer sales package until the early 1970's. As a result of antitrust settlements, manufacturers thereafter considered training a separate service that required a separate charge. Thus, the growing awareness of computer education costs led many

Table 3. Enlisted strength in Department of Defense computer specialties, 1971-79

Year	Total, computer specialties	ADP repairers	ADP support and administration[1]
1971	31,780	9,168	22,612
1972	29,591	8,516	21,075
1973	28,326	8,525	19,801
1974	26,736	7,860	18,876
1975	26,238	8,184	18,054
1976	22,843	7,683	15,160
1977	20,760	7,284	13,476
1978	20,433	7,353	13,080
1979	20,509	7,419	13,090

1 Includes computer operators, analysts, programmers, and electric accounting machine operators.

SOURCE: U.S. Department of Defense, Defense Manpower Data Center.

computer users to look for and closely evaluate alternative training methods in order to get the most for their computer education dollar.

One alternative for computer users was to train their own computer personnel. These "in-house" training programs generally took place at the user's site and were tailored to meet the specific needs of the company's computer operations. The programs were usually administered by company personnel or an educational services firm, and included instructional tools such as videotapes, cassettes, and self-paced computer manuals.

Another source of training for computer personnel was the Armed Forces. Although occupation-specific data are not available for years prior to 1971, the Armed Forces are believed to have been a major source of computer training during the 1950's and 1960's. As may be seen in table 3, however, the number of military personnel in computer-related job specialties declined sharply over the 1970's.

Computer education and training continued to evolve throughout the decade. In addition to the growing number of in-house training programs, the number of formal degree programs offered by colleges and universities increased dramatically in response to rising student interest and to requests from employers for graduates with a higher level of specific computer skills. The number of computer and information science programs offered at every degree level more than doubled over the period 1966-67 to 1978-79 (chart 6). Bachelor's degree programs experienced the most spectacular growth—554 percent. Associate degree programs in the computer fields grew 225 percent for the period. Growth in master's and Ph.D. programs was not as rapid as at the undergraduate levels—reflecting the strong demand for computer workers and the rising wages—but the number of programs still increased 162 percent and 117 percent, respectively.

Along with the growth in degree programs, the number of persons receiving degrees in the computer sciences also increased sharply. From 1970-71 to 1977-78, the total number of bachelor's, master's, and doctoral degrees in these fields grew from 4,104 to 12,060—a 194-percent increase (chart 7). Historical data by degree level for six computer curricula are presented in table 4.

The number of associate degrees awarded in data processing technologies fluctuated considerably in the 1970's (table 5). The number of associate degrees in all data processing technologies fell over the first half of the decade, then increased steadily over the remainder

Table 4. Number of college degrees conferred in the computer sciences by degree level and curriculum, 1970-71 through 1978-79

Degree level and year	Total, computer and information sciences	Computer information sciences, general	Information sciences and systems	Data processing	Computer programming	Systems analysis	Computer and information sciences, other
Bachelor's:							
1970-71	2,388	1,624	177	409	32	88	58
1971-72	3,402	2,451	268	504	8	72	99
1972-73	4,304	3,278	234	566	14	97	115
1973-74	4,756	3,761	338	539	15	54	49
1974-75	5,033	4,127	308	410	5	138	45
1975-76	5,652	4,530	493	483	3	89	54
1976-77	6,407	5,229	553	465	20	105	35
1977-78	7,201	5,940	742	395	24	61	39
1978-79	8,769	7,350	840	442	56	48	33
Master's:							
1970-71	1,588	1,131	143	171	5	88	50
1971-72	1,977	1,572	142	131	7	110	15
1972-73	2,113	1,627	115	144	0	153	74
1973-74	2,276	1,801	198	113	8	124	32
1974-75	2,299	1,921	147	114	0	79	38
1975-76	2,603	2,349	166	1	0	87	0
1976-77	2,798	2,580	149	6	0	60	3
1977-78	3,038	2,713	234	53	0	30	8
1978-79	3,055	2,773	183	51	0	23	25
Doctorate:							
1970-71	128	110	11	0	0	6	1
1971-72	167	145	16	0	0	6	0
1972-73	196	165	17	0	0	0	14
1973-74	198	178	13	0	0	0	7
1974-75	213	196	17	0	0	0	0
1975-76	244	221	20	0	0	3	0
1976-77	216	195	20	0	0	1	0
1977-78	196	183	13	0	0	0	0
1978-79	236	227	9	0	0	0	0

SOURCE: U.S. Department of Education, National Center for Education Statistics.

of the decade. Only two courses, computer programming and data processing equipment maintenance, registered any net growth over this period. This reflects the higher training requirements for programmer trainees and computer service technician trainees—some formal training generally is required—than for console and peripheral equipmemt operators, keypunch operators, and related workers. The decline in the number of degrees in these latter areas reflects the ability of many jobseekers to take entry level positions without any formal training. Some of those who chose to take formal training may have opted for public or private vocational programs that generally can be completed in less time than an associate degree and at a lower cost.

Public and private vocational schools provide another source of training. Because historical data are not available, it is difficult to determine whether vocational schools are growing in importance as a source of trained computer workers. Nevertheless, over 235,000 students were enrolled in these schools in 1978, with 9 of 10 enrolled in public vocational education programs (table 6). The number of persons —58,000—who completed these programs in 1978 was about 6 times the number of associate degrees awarded that year, greatly expanding the pool of jobseekers with at least some formal training.

Table 5. Associate degrees conferred in data processing technologies, 1971-72 through 1978-79

Curriculum	HEGIS code[1]	Associate degrees awarded							
		1971-72	1972-73	1973-74	1974-75	1975-76	1976-77	1977-78	1978-79
Total, data processing technologies	5100	8,971	7,640	6,998	6,821	7,176	7,993	9,339	10,833
Data processing technology, general	5101	5,669	4,584	4,360	3,921	3,981	4,671	5,095	5,974
Keypunch operator and other input preparation technology	5102	402	327	133	237	202	131	264	230
Computer programmer technology	5103	2,198	2,118	2,018	2,199	2,547	2,618	3,368	3,797
Computer operator and peripheral equipment operation technology	5104	431	249	205	240	229	304	263	475
Data processing equipment maintenance technology	5105	104	103	226	179	188	241	319	299
Other	5199	167	259	56	54	21	28	30	58

[1] HEGIS codes are from the Higher Education General Information Survey; see *A Taxonomy of Instructional Programs in Higher Education* (U.S. Department of Health, Education, and Welfare, 1970).

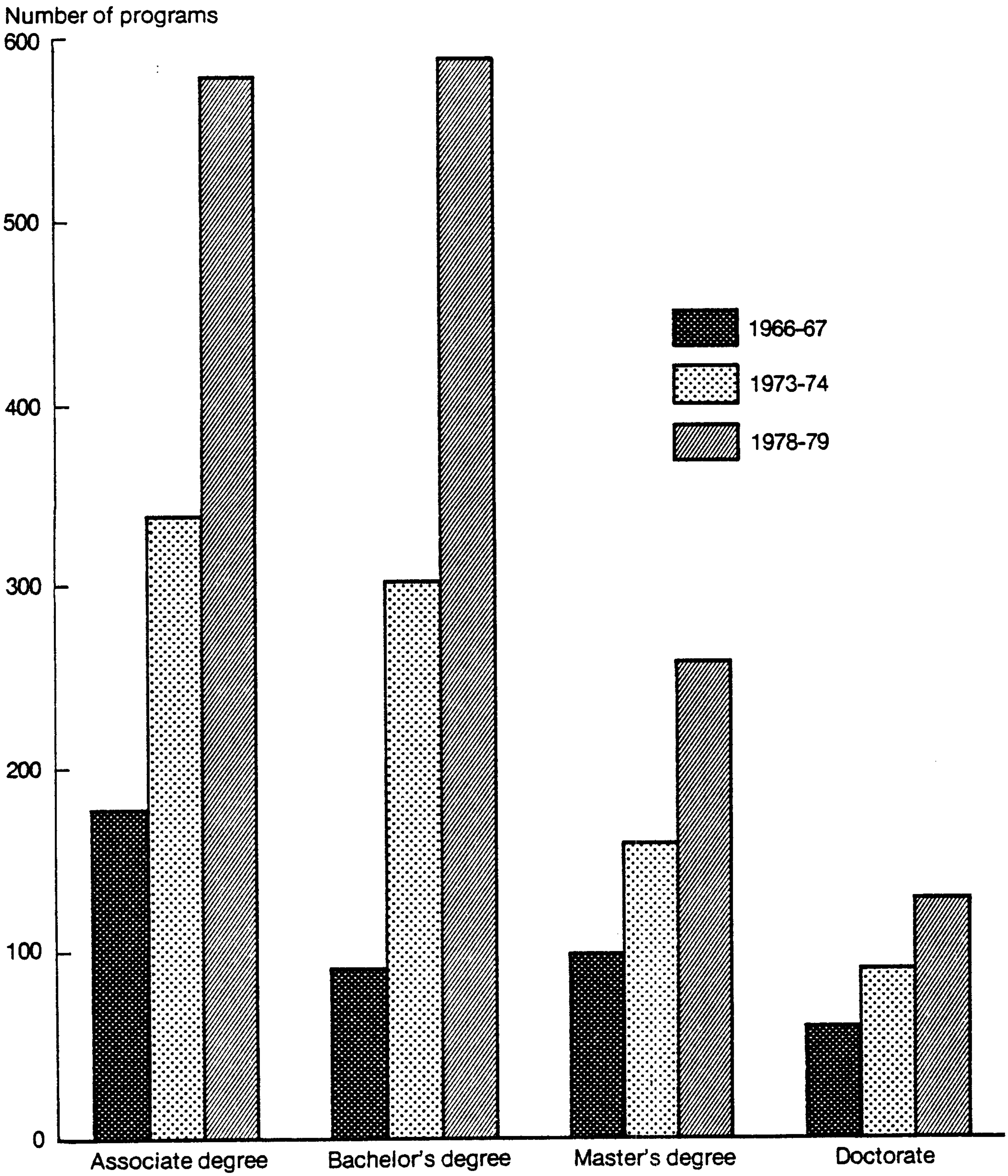
SOURCE: U.S. Department of Education, National Center for Education Statistics.

Table 6. Total enrollments and completions in public and private vocational programs, 1977-78

O.E. instructional code and title	Public vocational education		Private vocational education	
	Enrollments	Completions	Enrollments	Completions
Total	218,160	45,599	18,737	12,188
14.0201 Computer and console operator	50,666	11,519	785	627
14.0202 Keypunch operator	—	—	7,674	5,171
14.0203 Computer programmer	83,479	11,165	6,913	4,776
14.0299 Other business data processing	84,015	22,915	3,365	1,614

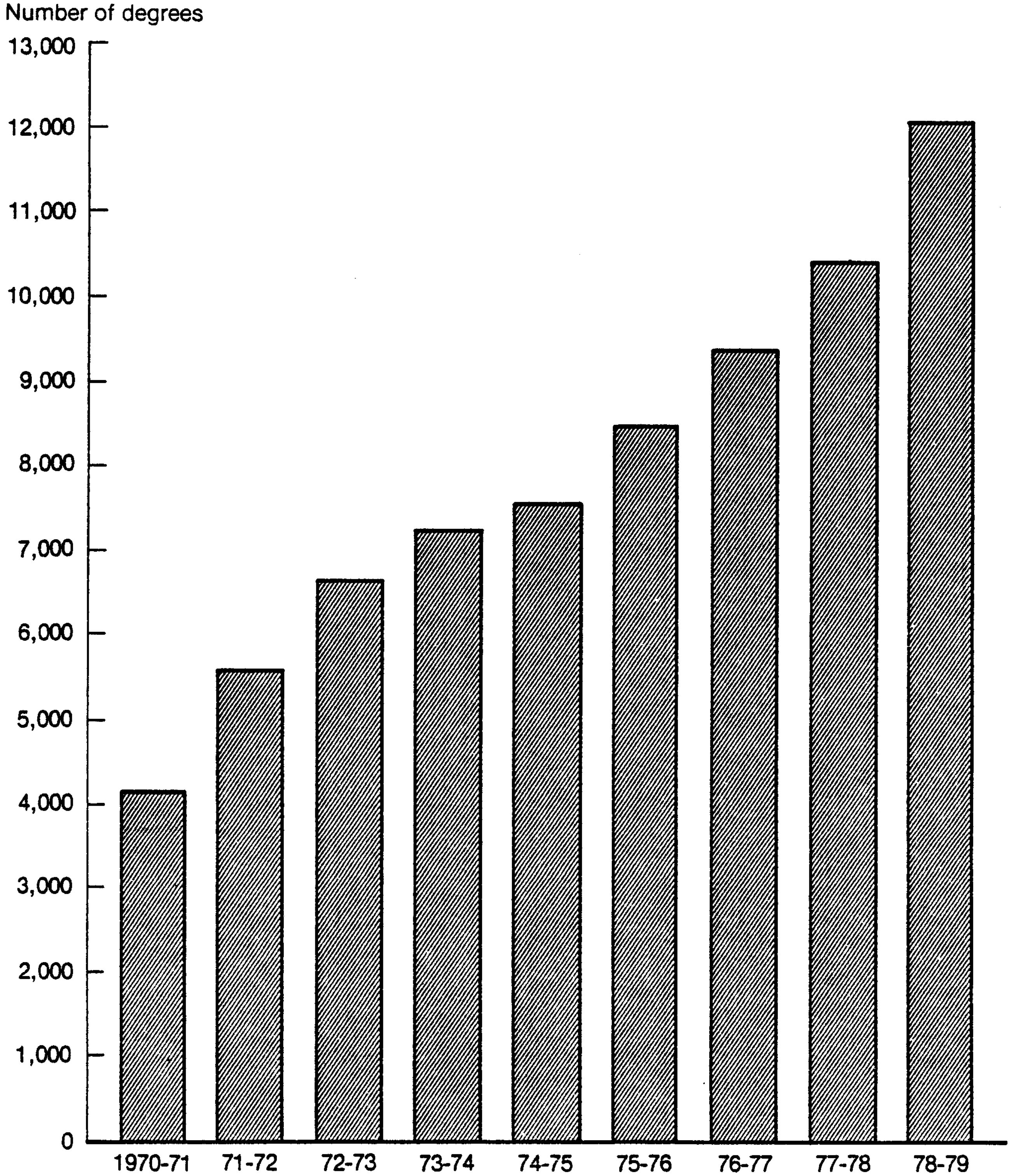
SOURCE: U.S. Department of Education, National Center for Education Statistics.

Chart 6. Number of college programs in the computer sciences by degree level, 1966-67, 1973-74, and 1978-79



Source: John W. Hamblen, *Computer Manpower—Supply and Demand—by States*, Table 1.

Chart 7. Number of bachelor's, master's, and doctoral degrees in the computer sciences, 1970-71 through 1978-79



Source: U.S. Department of Education, National Center for Education Statistics.

Chapter 3. Projected Employment Requirements

Even after the spectacular gains registered in the 1970's, overall employment in the computer occupations is expected to increase by nearly one-half from 1980 to 1990 (chart 8).

Technological factors affecting growth

Rapid technological progress is expected to continue over the next decade—affecting the types of computers available, computer applications, and the size and composition of computer occupations. New technologies that will affect employment can be divided into three major areas: Hardware (computer mainframe and peripheral equipment), software (computer programs and languages), and applications. These areas are all interrelated; advances in any one area generally have major implications for the others. The development of more efficient hardware, for example, can generate a whole spectrum of new applications. Elements in each of these three areas that are expected to have a significant impact on employment in the computer field are discussed in the following sections.

Hardware. Recent advances in semiconductor technology have spurred the development of computer components that are smaller in size but have greater memory and more available functions. In addition, prices have declined to the point where hardware costs are less than computer personnel costs in most data processing department budgets. These technological advances have led to new types of computer hardware as well as major improvements to existing hardware. Three major technologies that are expected to have a significant impact on computer employment are discussed in this section: Computer terminals, optical character recognition equipment, and minicomputers.

Improvements in the efficiency of computer terminals have resulted in a rising utilization of this type of equipment. The number of installed terminals is expected to increase from just over 2 million at the end of 1978 to almost 5 million by the end of 1983.[4] Terminals can be applied to many present computer systems, improving present applications or making possible new applications involving the transfer of data from one location to another for processing.

[4] International Data Corporation, *Special Report: Computer Industry Review and Forecast 1974-1983* (Waltham, Mass.).

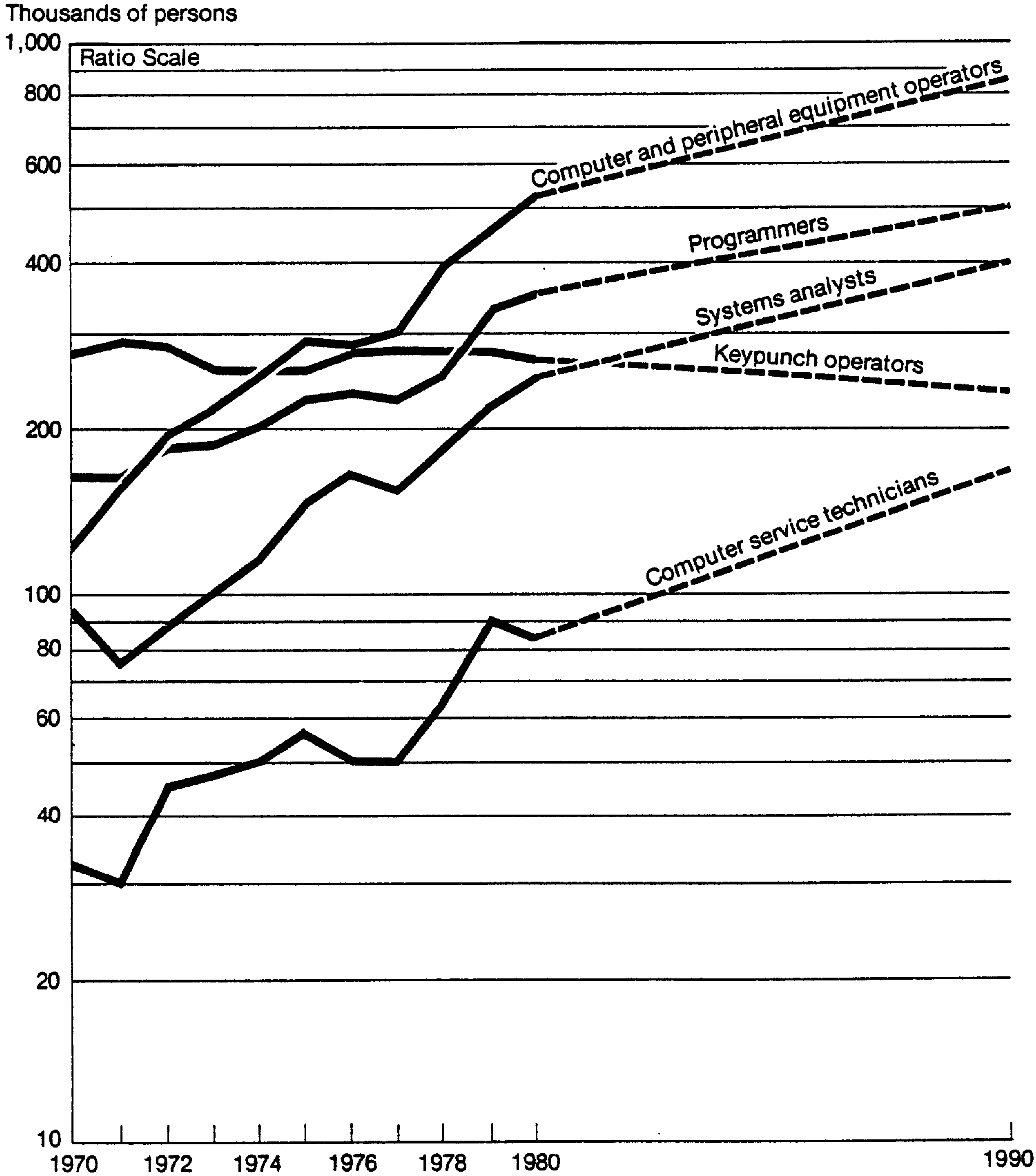
Among the computer occupations, increased terminal use will have its greatest impact on keypunch operators. Fewer of these workers will be needed, as data entry operations continue to move from card punch to more efficient on-line data entry systems. Airlines, for example, routinely use terminals at their ticket sales locations that are linked by data communications systems to a central computer. Data are entered directly into the central computer by reservation and ticket agents instead of keypunch operators who traditionally have worked at the central computer site. This example illustrates another important facet of computer terminal usage—terminals are expected to have a greater impact on noncomputer occupations than on computer occupations. As new applications are developed for terminals, more and more workers in noncomputer jobs will have to adapt to using terminals. Bank tellers and loan officers, for example, increasingly will operate terminals connected to the bank's central data base, and newspaper reporters and editors will use terminals in their work as well.

Optical character recognition equipment (OCR) provides another form of computer data entry. OCR equipment "reads" printed information in various forms and translates that information into computer input form. These machines can enter data into a computer system at a very high speed. This equipment, however, was slow in gaining acceptance due to its high cost and the limited number of typefaces it could recognize. Recent advances in microprocessor technology have reduced the cost of this equipment. Additionally, OCR equipment gained greater acceptance in the marketplace with the introduction of hand-held scanners, which have exposed more users to the accuracy and ease of use of this data entry technique.

Although applications for this equipment are still somewhat limited, an expanded product line that now includes three types of OCR equipment has contributed to the development and acceptance of a growing number of new applications. Each type of equipment, of course, has applications for which it is best suited.

- Page readers can identify characters at various locations on a sheet of paper. Page readers originally were used in the printing and publishing industries, but applications now have been developed for other businesses, such as insurance, where forms are sent in for processing to a

Chart 8. Employment of computer workers by occupation, 1970-80 and projected 1990



Source: Bureau of Labor Statistics.

central location from points all over the country.

- Document readers can recognize a few lines of information on a single pass. The major application of document readers is for billing purposes. Major users include credit card companies and public utilities.
- Hand-held scanners, which are mainly used in department stores in conjunction with point-of-sale terminals, are passed over an item manually to pick up pricing and inventory information. Other users include libraries, where these scanners are used to check out books, and businesses, for inventory and production control.

Although not technically considered OCR equipment, other forms of character recognition equipment have gained increased acceptance in recent years.

- Bar code readers recognize printed vertical bars of varied sizes. This equipment is mainly used in grocery stores to read the Universal Product Code.
- Optical mark readers (OMR) detect the presence or absence of marks at specific locations on a document. Their most common application is in educational testing. Utilities also use this technique for reading meters.
- Magnetic ink character recognition equipment (MICR) senses characters printed in a magnetic ink. The best example is found in banks, which use MICR for check clearing.

In general, the widespread use of these character recognition technologies will not have a major effect on the overall employment of computer workers. The impact on keypunch operators, however, almost certainly will be negative as these data entry techniques increasingly replace card punching.

Minicomputers {(minis) are yet another rapidly growing technology in the computer field. The value of minicomputer shipments by U.S. manufacturers is expected to more than triple between 1978 and 1983—increasing from $3.1 billion to $10.3 billion (chart 9). These machines, once defined as inexpensive, single-purpose computers, now encompass a wide range of capabilities and functions.

Small businesses—relative newcomers to the computer market—will increasingly use minicomputers as hardware costs continue to decline and more applications are developed. Small businesses use minis for general applications such as personnel administration, inventory control, payroll, and general business planning, as well as for industry-specific applications such as optimizing fertilizer and other crop input requirements and projecting insect activity in agricultural production.

Large businesses, especially those with widely scattered field offices, such as insurance companies, also will utilize more minis—often in conjunction with their central computer. These distributed data processing systems give processing capabilities to data users who can immediately use the information. They permit data entry and manipulation by workers at different locations, thus increasing the efficiency and flexibility of field operations.

Increased minicomputer utilization will have employment implications for all the computer occupations. A greater amount of equipment in operation can be expected to spur demand for computer and peripheral equipment operators and computer service technicians. More systems analysts and programmers also will be needed to design systems using this equipment and to develop programs for the ever-increasing number of applications. Keypunch operator employment, however, will be negatively affected as minis increasingly are used for on-line data entry.

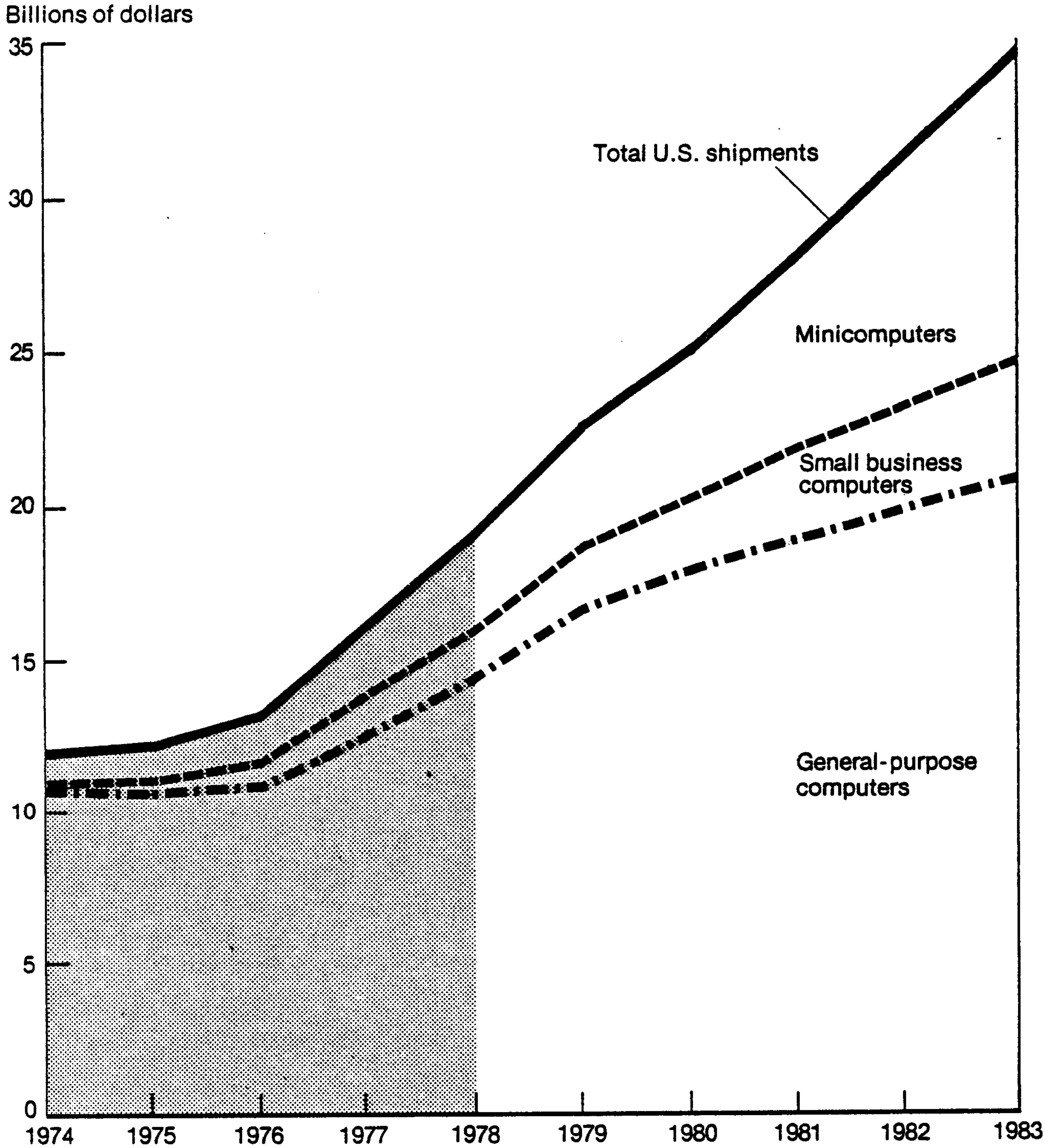
Software. Computer software will continue to evolve rapidly in a number of areas, resulting in increased productivity for many computer users. These software advances also will affect specific computer occupations, especially programmers and systems analysts. While there will be continued strong demand for these workers, their specific job duties may be affected. Software developments also will continue to make the computer more accessible to workers in such fields as publishing and medicine.

One trend in software technology has been the incorporation of systems programming functions into computer hardware. If this trend continues over the next decade, it may curb the demand for some systems programmers. Overall demand for programmers, however, will remain strong—allowing these workers to shift to other types of programming.

Packaged programs are another software option available to computer users. These programs, which are being developed for an ever-increasing number of applications, simplify programming operations, reduce programmer skill requirements, and may require fewer programmers at a computer site. In some instances, certain programming operations may be simplified to the point where they could be performed by computer operators. These packaged programs also will permit programming to be done by noncomputer personnel in many cases.

Another promising area for software improvement is in the development of user-oriented, high-level computer languages. Thus far, research in this area has not produced all of the desired results. COBOL, for example, was a language developed for use by managers in business applications, but in practice it has proved to be too complex for this purpose. Advances have been made in this area, however, that allow noncomputer personnel to bypass programmers and have direct access to the computer. Table Producing Language (TPL), for example, now allows noncomputer workers such as social scientists to use computers in their daily work. Improved hardware and further advances in

Chart 9. Value of computer systems produced by U.S. manufacturers by type of computer, 1974-78 and projected 1979-83



Source: International Data Corporation.

software technology may lead to the development of even more high-level languages.

Applications. Increases in the number of applications will be the main stimulus to computer employment growth over the next decade. Although progress in hardware and software technology may temper the demand for computer workers at some computer sites, these same technological advances are expected to bring the computer within reach of an increasing number of users.

Some new applications will be made possible with the continued development and refinement of new computer hardware. For example, computers can be applied to point-of-sale operations in supermarkets or department stores through the use of computer terminals, character recognition equipment, and other types of data communications equipment. Data communications networks also will permit traditional computer users to develop and implement new computer applications. Banks, for example, will increasingly use terminals for electronic funds transfer systems (EFTS).

Along with the introduction of new hardware, the cost of computer equipment has dropped dramatically in recent years. These reductions in hardware costs are expected to continue, allowing more relatively small organizations to utilize computers. These newcomers will use the computer for traditional functions, such as accounting and inventory control. Additonally, they will have new, industry-specific applications, creating more jobs for computer personnel over the next decade. Small oil and gas exploration firms, for example, are increasingly using computers for such specialized applications as production statistics, land lease data, and geologic and engineering applications.

New software developments, such as higher level, easy-to-use languages, will continue to make the computer more accessible. This will increase the number of potential computer users, especially small businesses. Also, more industries will become computerized as packaged programs are developed for their specific applications.

As may be seen from the above, hardware, software, and applications are all interrelated. While hardware and software developments may appear to curb the demand for some computer workers due to increased productivity, this is only a small part of the overall story. Far more important in terms of employment impact will be the expanding number of applications made practical by these hardware and software advances. As the computer is made accessible to more users through these developments, many more computer workers will be needed.

Expected employment growth by occupation

In general, a greater variety of applications, advancing software technology, and more efficient computer hardware all lead to a greater utilization of computer equipment, which will result in a growing demand for computer personnel over the next decade. Table 7 presents employment projections for each of the computer occupations. Increasing applications and greater amounts of hardware, for example, are expected to spur the employment of computer and peripheral equipment operators and computer service technicians. At the same time, changes in data entry methods will reduce the demand for keypunch operators. A summary of the employment outlook for each computer occupation follows.

Systems analysts. Employment of systems analysts is expected to increase from 243,000 in 1980 to 400,000 in 1990, or by 65 percent.

The history of computers has been marked by many unsuccessful attempts to solve problems, reduce costs, and increase productivity. A major cause of such failures has been the lack of adequate systems analysis and design to take full advantage of computer capabilities. As the requirements of computer users continue to escalate, they will demand greater efficiency and increased performance from their computer systems. Similarly, computer hardware and software advances will increase computer application possibilities and the compatibility of equipment from different sources. These advances also will permit "networking" or other equipment interrelationships, such as distributed data processing, in new and existing computer systems. As a result, systems analysts, who have always been in great demand, will continue to be sought to reduce computer systems

Table 7. Employment in computer occupations, 1980 and projected 1990

Occupation	1980 employment	Projected 1990 requirements	Percent change, 1980-90
Total, all occupations	1,455,000	2,140,000	47.1
Systems analysts	243,000	400,000	64.6
Programmers	341,000	500,000	46.6
Computer and peripheral equipment operators	522,000	850,000	62.8
Keypunch operators	266,000	230,000	−13.5
Computer service technicians	83,000	160,000	92.8

SOURCE: Bureau of Labor Statistics.

problems and develop more sophisticated and complex computer operations.

Programmers. Computer programmer employment is expected to grow from 341,000 in 1980 to 500,000 in 1990, an increase of 47 percent. The overall demand for programmers will increase as less expensive and more sophisticated computer hardware and software attract new computer users and increase the number and type of computer applications among existing users.

More systems programmers will be needed to develop the complex operating programs made necessary by higher level languages and complicated computer configurations, as well as to link or coordinate the output of different programs from different systems. As increasing applications expand the computer market, the need for applications programmers also will increase, although not quite as rapidly as in the past as more people use "canned" programs to process data without the direct assistance of a programmer. Continuing development of programming instructions built into computer hardware, user-oriented languages, terminal programming by non-EDP personnel, and more standardized software packages are expected to simplify some job duties of applications programmers.

Computer and peripheral equipment operators. Employment of computer and peripheral equipment operators is expected to increase from 522,000 in 1980 to 850,000 in 1990, or by 63 percent. The major cause of this growth is the increasing use of computer hardware. The increased utilization of distributed data processing systems, and the concomitant rise in the number of minicomputers and other types of peripheral equipment, also will require increasingly large numbers of computer operating personnel.

Similarly, recent advances in miniaturizing circuits have enabled manufacturers to reduce both the size and cost of computer components. As the technology is further developed, a continued expansion in the use of computers is expected, especially by small businesses. As small business applications increase, many of these organizations are expected to install their own computer systems, thus generating additional demand for workers to operate the equipment.

Keypunch operators. Employment of keypunch operators is expected to decline from 266,000 in 1980 to 230,000 by 1990. This 14-percent decrease is the only projected employment decline among the computer occupations studied.

Data entry has long been considered a bottleneck in data processing operations. Cardpunch-oriented data entry systems in the past have produced slow, error prone, and increasingly costly performance in many computer operations. Further, the gap between machine speed and the time required for manual card input has widened due to advances in internal data processing capabilities of computers. These problems, along with expected increases in the volume of data to be processed, have spurred technological advances in alternative methods of data entry. These methods include computer terminals and other forms of direct keying, along with other data communications input systems. Users are expected to continue to employ these more efficient data entry methods, thus diminishing the need for keypunch operators.

Computer service technicians. Employment of computer service technicians is expected to show the largest increase of all the computer occupations—growing from 83,000 in 1980 to 160,000 in 1990, or by 93 percent.

The rising demand for computer service technicians is related to the growing number of computers in use and the geographic distribution of these computers. Continued reductions in the size and cost of computer hardware will bring the computer within reach of a rapidly increasing number of small organizations. As more and more of these small systems are installed, the amount of time technicians must spend traveling between clients also will increase, further intensifying the demand for these workers.

Expected employment growth by major industry division

Although computer employment is expected to grow substantially in all industries over the next decade, considerable variation is expected. Table 8 presents 1978 and projected 1990 computer employment by major industry division. The following sections describe the factors underlying computer employment growth in each of these industry groups.[5]

Manufacturing. Computer employment in manufacturing is expected to increase rapidly - by about 70 percent—over the period 1978 to 1990. Because computers are readily adaptable to manufacturing processes, this industry division had already made extensive use of computers by the early 1970's. Over the next decade, the manufacturing sector will continue to apply computers to process control, quality control, business forecasting, and management information functions such as accounting and personnel management. In addition, more intensive use will be made of existing systems; many of these will require additional computer personnel. Also, minicomputer systems will continue to be developed for specific manufacturing functions, such as product design and precision measurement. Some of

[5] As indicated earlier, the latest industry-occupational matrix available when this report was prepared presented employment of computer workers by industry for 1978. This section, therefore, describes employment change between 1978 and 1990.

Table 8. Employment in computer occupations by industry division, 1978 and projected 1990

Industry division	Total, all occupations			Systems analysts			Computer programmers		
	1978	1990	Percent change, 1978-90	1978	1990	Percent change, 1978-90	1978	1990	Percent change, 1978-90
Total, all industries	1,157,983	2,140,000	84.8	181,998	400,000	119.8	246,998	500,000	102.4
Agriculture, forestry, and fisheries	1,079	1,785	65.4	45	200	344.0	269	600	123.0
Mining	13,107	24,860	89.7	2,354	5,000	112.4	3,176	6,300	98.4
Construction	10,213	17,525	71.6	1,423	3,000	110.8	2,481	4,500	81.4
Manufacturing	320,270	552,400	72.5	61,915	119,500	93.0	73,830	129,000	74.7
Transportation, communication, and public utilities	65,505	107,130	63.5	8,215	17,700	115.5	12,445	23,000	84.8
Wholesale and retail trade	141,665	242,000	70.8	18,782	35,000	86.3	19,409	35,000	80.3
Finance, insurance, and real estate	152,498	266,900	75.0	14,358	30,100	109.6	26,300	51,000	93.9
Services	343,759	719,900	109.4	59,800	147,500	146.7	84,366	204,000	141.8
Government	116,695	207,500	77.8	21,914	42,000	91.7	24,722	46,600	88.5

Industry division	Computer service technicians			Computer and peripheral equipment operators			Keypunch operators		
	1978	1990	Percent change, 1978-90	1978	1990	Percent change, 1978-90	1978	1990	Percent change, 1978-90
Total, all industries	63,001	160,000	154.0	392,993	850,000	116.3	272,993	230,000	-15.8
Agriculture, forestry, and fisheries	5	10	100.0	337	625	85.5	423	350	-17.3
Mining	87	210	141.4	5,397	11,650	115.9	2,093	1,700	-18.8
Construction	95	200	110.5	3,641	7,725	112.2	2,573	2,100	-18.4
Manufacturing	15,914	44,000	157.6	103,093	215,000	108.5	65,518	47,900	-26.9
Transportation, communication, and public utilities	816	1,580	93.6	26,057	52,300	100.7	17,972	12,550	-30.2
Wholesale and retail trade	18,737	46,000	145.5	44,465	90,000	102.5	40,282	36,000	-10.6
Finance, insurance, and real estate	527	1,300	146.7	69,026	147,500	113.7	42,287	37,000	-12.5
Services	25,132	66,000	162.6	103,647	236,000	127.7	70,814	66,400	-6.2
Government	1,683	3,700	119.2	37,340	89,200	138.9	31,031	26,000	-16.2

SOURCE: Bureau of Labor Statistics.

the job functions traditionally carried out by computer personnel will be performed in the future by engineers, machinists, and other personnel using minicomputers.

Finally, computer terminals will be used more extensively but will have a mixed impact on computer employment. For example, terminals are used in warehouse inventory control and in research and development. Some data input will be handled by warehouse personnel and research scientists or engineers, decreasing the demand for keypunch operators. Greater terminal use, however, should increase the demand for systems analysts and programmers. Also, the larger amounts of computer equipment in use will further spur the need for additional computer service technicians.

Transportation, communications, and other public utilities. This industry division has been intensively computerized since the late 1960's. Consequently, it is expected to experience the smallest increase in computer employment through the 1980's, about 65 percent. Installing new computers and upgrading present computer systems—especially in the communications sector—will result in sharp employment increases for computer service technicians, systems analysts, and computer programmers. The demand for computer and peripheral equipment operators also is expected to increase with the greater utilization of computer terminals. The number of keypunch operators, however, is expected to decline, partially offsetting the gains registered in other occupations.

Wholesale and retail trade. Computer employment in wholesale and retail trade is expected to increase by about 70 percent, less than the average for all industries through the next decade. During the 1970's, both retailers and wholesalers increasingly adopted such practices as computerized ordering and inventory systems, as well as integrated point-of-sale credit authorization systems. These applications will gradually extend to the smaller establishments in the industry division, creating additional demand for computer workers.

Employment of systems analysts, programmers, and computer and peripheral equipment operators will all increase as small retailers and wholesalers increasingly computerize their operations. The largest percentage increase, however, is projected for computer service technicians due to the expected growth in the number of data processing terminals and associated communications devices. Employment of keypunch operators will decline as new data are captured at the source by noncomputer personnel such as sales clerks, or keyed in via terminals connecting branch outlets to the organization's main data base.

Finance, insurance, and real estate. Computer employment in this major industry sector will increase sharply through the 1980's—by 75 percent—as more small and medium-sized companies adopt computer techniques already widely used by larger firms in the industry. Most of this employment increase will occur in the finance sector. More banks are expected to automate their teller operations, participate in automated check clearing facilities, and offer 24-hour banking services through the use of on-line terminals. In addition, rapidly emerging banking applications such as electronic funds transfer systems (EFTS) will generate expansion of computer staffs in financial institutions. Increased participation in centralized credit checking and authorization systems will spur the demand for computer workers in credit agencies. Within finance, the group expected to show the smallest employment gains are securities firms. These firms were extensively computerized in the 1970's, with the implementation of fully automated stock quotation facilities and a national system for clearing securities transactions.

Although overall employment in finance, insurance, and real estate is expected to increase rapidly, growth rates for the individual occupations will vary. Employment of computer service technicians will increase the most rapidly, due to the large numbers of terminals, minicomputers, and other data communications equipment in operation. The demand for systems analysts, programmers, and computer and peripheral equipment operators also will remain very strong as the industry continues to increase the number and types of applications as well as the volume of computer equipment. Keypunch operator employment will decline as more efficient methods of data entry are adopted.

Services. Services, the fastest growing industry division in the economy, are expected to show the greatest increase in computer employment through the 1980's; employment is expected to more than double over the period. An expanding market for data processing in hospitals, educational institutions, and, especially, computer service organizations will account for most of the increase. Demand for programmers and systems analysts will be strong as hospitals continue to computerize their medical information and communications systems, as well as automating the services they provide to patients. Employment requirements of these systems and of those for medical diagnosis and instruction will assure the need for computer specialists in hospitals.

Similar growth is expected in educational services as more computer-assisted instructional systems are developed, library operations such as acquisitions and cataloging continue to be automated, and administrative tasks including class scheduling and maintenance of student records are handled by computers. Because many medical and educational applications are expected to feature direct data entry by users, such as hospital record clerks or students, employment requirements for keypunch operators should decline.

The growth of computer service organizations also will contribute heavily to the overall increase for computer workers in this industry. Service firms will continue to need large numbers of computer and peripheral equipment operators as well as more systems analysts and programmers to design and implement systems for the growing number of applications for small businesses and other organizations. At the same time, computer maintenance companies will need many more computer service technicians to service the increasing stock of computer equipment. Several factors will contribute to a growing need for contract data processing services and the resulting demand by service firms for trained computer personnel. These sources of demand include a growing number of applications featuring computer-to-terminal interfacing or minicomputers, and the growing popularity of franchised data processing services that are expected to enlarge the market.

Several other sectors within this broad industry division will experience growth in computer employment. Hotels, for example, will continue to install computerized reservation systems; and business services such as accounting, credit reporting, and research will become increasingly computerized.

Government. Computer employment requirements in government will increase by about 80 percent through the 1980's, as new information systems are installed and existing ones expand their capabilities. State and local government agencies will experience the greatest growth in computer personnel as their potential for new computer applications is realized. Growth in Federal computer employment will be somewhat slower, but steady nevertheless, as data processing requirements continue to expand.

Currently, most State and local computer systems have been developed around a single functional area such as revenue collection and disbursement, payroll, or medical and insurance information processing. In the future, however, consolidated systems serving a greater variety of information processing needs and using terminal networks and other data communications technology will be developed.

Within government, employment of computer service technicians will grow dramatically—keeping pace with hardware sales and installations. Larger amounts of equipment in use will also spur the demand for computer and peripheral equipment operators. Requirements for programmers and systems analysts, especially at the State and local level, will also rise rapidly as law enforcement, voter registration, and traffic-oriented applications continue to be computerized. Keypunch operator employment, however, will decline as more efficient methods of data entry continue to be utilized.

Agriculture, forestry, and fisheries, mining, and construction. The number of people employed in the computer occupations in these industry divisions is so small that accurate employment projections cannot be made. It is expected, however, that computer employment in these industries will exhibit the same trends as in the overall economy.

Job openings

In addition to openings resulting from growth in the demand for computer workers, many jobs will become available each year as workers retire, die, leave the labor force for other reasons, or transfer to other occupations. Data on estimated annual job openings between 1980 and 1990 are presented in table 9. Total openings for each occupation consist of those resulting from employment change in that occupation and those stemming from the need to replace workers who leave the labor force for a variety of reasons. Although keypunch operator employment is expected to decline, for example, there will be many job openings in this large occupation as workers die or retire.

Sufficient data are not available to develop estimates of openings resulting from transfers of workers to other occupations. The limited data that are available, however, indicate significant mobility both within the computer field and for computer workers who transfer to other kinds of jobs. Programmers, for example, often advance to systems analyst jobs and many systems analysts become managers. To a lesser extent, a career ladder exists for computer operating personnel, with some of these workers advancing to programmer positions.

Implications of employment projections

The extremely rapid employment growth projected for the computer occupations will have a significant impact on education and training, wages, and other aspects of the labor market for computer workers. Some foreseeable trends are:

- The educational system will need to develop more programs to meet the continually rising demand for computer workers. Additionally, as computer use becomes more widespread, the trend toward infusing computer-related training into more curricula will accelerate.
- Shortages of computer workers are expected to become increasingly pronounced in the years ahead. As more and more workers are required to bring new computer applications on-line, competition among employers for skilled computer personnel will become increasingly intense. Thus, firms are likely to continue using aggressive recruiting techniques to fill their computer staffing requirements.
- The shortage of trained computer personnel is likely to result in a continued escalation of wages for these workers. Not only will entry salaries be driven up, but also the salaries of experienced workers in order to maintain an organization's internal salary structure.
- The great demand for computer personnel will make it more difficult to hire and retain workers in occupations requiring similar aptitudes. Math teachers, for example, are being lured away from public schools by the higher salaries in computer specialties. Colleges and universities also are finding it difficult to compete with business and government organizations to attract and retain computer science professors who may earn less than a beginning programmer. As the continuing upward pay spiral further discourages graduate study, schools will find it increasingly difficult to alleviate the teacher shortage.
- As electronic data processing operations grow in importance across all industries, the importance of and opportunities for skilled computer workers also will increase. Many companies, for example, now include data processing managers on their executive boards, a practice almost unheard of a decade ago. As data processing budgets expand and the coordination of computer operations becomes more complex, opportunities of this type are expected to become more prevalent.

In summary, the shortage of computer personnel is expected to continue, resulting in higher wages, more job mobility, increased job security, and generally greater opportunities for these workers. At the same time, this labor market imbalance will result in serious problems for employers as they attempt to maintain a stable computer staff.

Table 9. Projected average annual job openings in computer occupations, 1980-90

Occupation	Total average annual openings, 1980-90	Employment change	Replacement needs[1]
Total	93,700	68,500	25,200
Systems analysts	19,000	15,700	3,300
Programmers	20,550	15,900	4,650
Computer and peripheral equipment operators	41,800	32,800	9,000
Keypunch operators	3,900	-3,600	7,500
Computer service technicians	8,450	7,700	750

[1] Separations from the labor force due to deaths and retirements.
SOURCE: Bureau of Labor Statistics.

Appendix A. Methods

Sources of data

Data for this study were obtained from several sources. First, interviews were conducted with officials of the American Federation of Information Processing Societies, the International Data Corporation, and others. Various experts, including educators and government officials, also were interviewed.

Next, a search of existing literature was made to obtain available information on the employment and training of computer personnel. In addition, information was sought on computer use by specific industry, types of computer applications, and advances in computer technology.

These sources were supplemented by data from the Bureau of the Census and BLS, especially the BLS national industry-occupational matrix that provides detailed information on the distribution of occupational employment by industry. The employment projections presented in this report represent an interim revision of portions of that matrix to reflect the results of the study.

Framework for projections

Projections of employment for the economy as a whole and by industry were prepared by BLS and described in *Employment Projections for the 1980's*, BLS Bulletin 2030. A brief description of the assumptions that underlie these projections is presented in *Occupational Projections and Training Data*, BLS Bulletin 2052.

Computer employment projections presented in this study were developed within the framework of the latest BLS industry-occupational matrix. The most recently developed matrix presents data on occupational composition of all industry sectors for 1970, 1978, and 1990. Matrix staffing patterns reflect the 1970 Census industry-occupational employment estimates, updated by the Bureau's Current Population Survey that provides census-based occupational estimates for the years between the decennial censuses.

In-depth analysis of the computer occupations and evaluation of trends in the computer field led to an upward revision of the 1990 matrix employment projections for each of the computer occupations. These revised projections were then applied to the 1990 estimates of total employment for each of the 200 industries included in the matrix to yield new ratios showing the concentration of each computer occupation in each industry. The total number of computer workers per industry was obtained by summing across all of the computer occupations.

Change in matrix data base

The BLS is in the process of converting from an industry-occupational matrix based on census data to one based on the Occupational Employment Statistics (OES) survey.[1] These two data sources differ in several major respects:

Respondents. The census-based Current Population Survey (CPS) is a household survey, completed by an individual who responds for all members of the household. Persons who hold two or more jobs are only counted once, based on where they work the most hours each week. The OES survey is an establishment survey in which an official of the responding firm completes a questionnaire based on company records. Data from the OES survey count all jobs in each surveyed industry.

Time frame. Industry staffing patterns are available from the Census only every 10 years. The OES surveys are updated on a 3-year cycle, with staffing patterns benchmarked to the third year of the cycle.

Occupations. The CPS collects employment data for approximately 400 occupations. The data are categorized according to job titles that were used in the 1970 Census. The OES survey collects data for more than 1,800 occupations. Each occupation to be surveyed in a particular industry is defined on the questionnaire for that industry.

Industries. The CPS does not collect occupational employment by detailed industry. Staffing patterns from the latest decennial Census are updated based on estimates of occupational employment from the CPS and on estimates of industry employment from the Industry Employment Statistics (IES) survey. This produces occupational employment data for 200 industries. The OES survey collects occupational employment by detailed industry. Data are not collected in the agricultural or

[1] A background discussion of the OES survey may be found in the *BLS Handbook of Methods*, Bulletin 1910 (1976), pp.57-59.

private household industries—these are estimated. This procedure generates occupational employment data for 378 industries.

Preliminary findings indicate that the two surveys reported comparable levels of employment in 1978 for all of the computer occuptions except computer and peripheral equipment operators. Preliminary OES survey results show substantially fewer of these workers than were reported in the 1978 CPS. Differences in occupational classification are the most likely explanation for the different employment estimates. The 1970 Census lists general job titles (some of which are now outdated) that the respondent has to fit to job duties, whereas the OES survey has a specific definition included on each questionnaire that probably eliminated a number of workers from this category.

Table B-1. Industry distribution of computer employment by occupation, 1970, 1978, and projected 1990

Industry	Total, all computer occupations						Computer programmers					
	1970		1978		1990		1970		1978		1990	
	Employment	Percent of industry employment	Employment	Percent of industry employment	Employment	Percent of industry employment	Employment	Percent of industry employment	Employment	Percent of industry employment	Employment	Percent of industry employment
Total, all industries	765,183	0.97	1,164,791	1.23	2,140,000	1.88	176,496	0.22	246,998	0.26	500,000	0.44
Agriculture, forestry, fisheries	687	.02	1,079	.03	1,785	.06	149	–	269	.01	600	.02
Agriculture	419	.01	564	.02	865	.03	47	–	72	–	200	.01
Agricultural production	154	–	161	.01	230	.01	–	–	–	–	20	–
Services, except horticulture	225	.13	327	.14	500	.16	39	.02	52	.02	130	.04
Horticultural services	40	.03	76	.03	135	.06	8	.01	20	.01	50	.02
Forestry	149	.28	473	.59	775	1.09	90	.17	179	.23	350	.49
Fisheries	19	.04	25	.04	145	.23	12	.03	18	.03	50	.08
Mining	6,114	.97	13,107	1.48	24,860	2.35	1,752	.28	3,176	.38	6,300	.59
Metal mining	500	.53	646	.68	1,125	1.00	132	.14	159	.17	300	.27
Coal mining	179	.12	391	.18	700	.21	31	.02	55	.03	100	.03
Crude petroleum and natural gas	5,037	1.80	11,479	2.53	21,935	4.47	1,494	.54	2,847	.63	5,700	1.16
Nonmetallic mining, quarrying	398	.34	591	.48	1,100	.95	95	.08	115	.09	200	.17
Construction	7,045	.15	10,213	.17	17,525	.25	1,864	.04	2,481	.04	4,500	.07
General building contractors	852	.07	1,269	.09	2,425	.14	202	.02	312	.02	600	.03
General contractors, exc. building	5,274	.38	7,332	.47	12,385	.64	1,497	.11	1,855	.12	3,250	.17
Special trade contractors	919	.04	1,612	.06	2,715	.08	165	.01	314	.01	650	.02
Manufacturing	238,399	1.21	320,270	1.56	552,400	2.34	60,615	.31	73,830	.36	129,000	.55
Durable goods	169,844	1.49	235,027	1.90	421,700	2.90	47,474	.42	58,043	.47	104,500	.68
Ordnance	8,612	2.91	6,923	4.02	10,400	6.02	3,221	1.09	2,143	1.24	4,000	2.31
Lumber and wood products	1,439	.23	1,841	.27	2,850	.39	294	.05	381	.06	490	.07
Logging	71	.06	99	.08	140	.13	25	.02	36	.03	40	.04
Sawmills, planing mills	951	.24	1,136	.27	1,580	.34	195	.05	254	.06	290	.06
Misc. wood products	417	.34	606	.46	1,130	.67	74	.06	91	.07	160	.09
Furniture and fixtures	2,237	.48	3,011	.58	4,550	.67	388	.08	529	.10	820	.12
Stone, clay, and glass products	3,732	.58	4,983	.71	8,120	1.14	719	.11	895	.13	1,450	.20
Glass and glass products	1,214	.66	1,488	.74	2,460	1.11	254	.14	311	.15	560	.25
Cement, concrete, plaster	1,252	.56	1,727	.70	2,770	1.06	307	.14	385	.16	590	.23
Structural clay products	193	.33	188	.37	230	.72	37	.06	37	.07	40	.13
Pottery and related products	190	.43	272	.58	500	1.18	21	.05	27	.06	30	.07
Misc. nonmetallic stone	883	.66	1,308	.86	2,160	1.40	100	.07	135	.09	230	.15
Primary metal industries	11,043	.85	13,515	1.08	20,900	1.55	2,202	.17	2,549	.20	4,100	.30
Blast furnaces, steel works	5,402	.97	6,028	1.25	8,620	1.80	1,048	.19	1,129	.23	1,620	.34
Other primary steel	1,982	.54	2,499	.68	4,040	.95	404	.11	478	.13	840	.20
Primary aluminum	1,519	.97	2,275	1.27	3,690	2.04	324	.21	426	.24	730	.40
Other primary nonferrous	2,140	.98	2,713	1.19	4,550	1.76	426	.19	516	.23	910	.35
Fabricated metal products	9,989	.72	13,874	.90	22,670	1.21	1,960	.14	2,589	.17	4,550	.24
Cutlery, other hardware	1,664	1.10	2,209	1.23	3,510	1.54	267	.18	387	.20	690	.30
Fabricated metal products	2,799	.65	3,949	.79	6,780	.98	610	.14	825	.16	1,670	.24
Screw machine products	865	.83	1,075	.99	1,530	1.35	120	.11	147	.14	220	.19
Metal stamping	1,446	.62	2,142	.87	3,690	1.27	321	.14	407	.17	670	.23
Misc. metal products	3,215	.69	4,499	.88	7,160	1.32	642	.14	843	16	1,300	.24
Machinery, except electrical	56,319	2.85	90,982	3.93	199,680	6.70	17,098	.86	24,318	1.05	51,190	1.72
Engines and turbines	1,551	1.41	2,354	1.78	4,190	2.93	394	.36	560	.42	890	.62
Farm machinery, equipment	2,004	1.56	2,747	1.84	4,680	2.60	429	.33	572	.38	920	.51
Construction machinery	3,847	1.31	6116	1.65	10,240	2.19	851	.29	1,253	.34	1,950	.42
Metalworking machinery	3,041	.96	4,488	1.29	7,820	1.79	759	.24	1,011	.29	1,900	.44
Office, accounting machinery	4,849	5.33	4,980	6.91	6,670	10.13	1,304	1.43	1,156	1.60	1,600	2.43
Electronic computing equipment	33,025	17.57	58,322	21.72	145,420	30.94	11,626	6.19	17,388	6.49	39,960	8.50
Machinery, n.e.c.	7,922	.93	11,975	1.23	20,660	1.67	1,735	.20	2,378	.24	3,970	.32
Electrical machinery	35,815	1.87	47,031	2.29	78,670	3.15	10,751	.56	12,002	.58	19,900	.80
Household appliances	1,958	1.06	2,370	1.30	3,940	1.85	407	.22	464	.25	620	.29
Radio, TV, communications equipment	15,891	2.52	18,763	3.14	27,100	4.12	5,062	.80	5,128	.86	7,300	1.11
Electrical machinery, n.e.c.	17,966	1.63	25,898	2.03	47,630	2.92	5,282	.48	6,410	.50	11,980	.73
Transportation equipment	28,727	1.50	35,814	1.73	50,650	2.14	8,172	.43	8,982	.43	12,200	.51
Motor vehicle equipment	9,111	1.13	13,827	1.41	22,400	1.96	1,999	.25	2,855	.29	5,180	.45
Aircraft and parts	16,706	2.51	18,213	3.10	22,540	4.39	5,448	.82	5,316	.91	5,990	1.17
Ship, boat building, repair	2,196	.80	2,592	.92	3,680	1.17	586	.21	594	.21	680	.22
Railroad equipment	445	.88	661	1.06	990	1.55	94	.19	125	.20	150	.23
Mobile dwellings	106	.12	195	.18	430	.16	8	.01	15	.01	40	.01
Cylces, misc. transportation equipment	163	.65	326	.77	610	.93	37	.15	77	.18	160	.24
Professional and scientific instruments	8,180	1.80	12,558	2.22	19,980	2.92	2,092	.46	2,956	.52	4,870	.71
Scientific instruments	3,168	1.79	4,454	2.27	6,330	3.23	816	.46	1,051	.54	1,430	.73
Optical, health service supplies	1,876	1.38	3,428	1.66	5,710	2.14	461	.33	791	.38	1,550	58
Photo equipment and supplies	2,831	2.60	4,377	3.34	7,460	4.05	756	.69	1,040	.79	1,780	.97
Watches and clock devices	305	.97	299	.99	380	1.05	69	.22	74	.24	110	.30
Misc. manufacturing	3,552	.82	4,495	.97	5,930	1.18	577	.13	699	15	930	.18
Nondurable goods	68,755	.84	85,783	1.04	131,700	1.45	13,141	.16	15,787	.19	25,500	.28
Food and kindred products	11,169	.63	13,569	.79	20,020	1.15	1,903	.11	2,157	.13	3,390	.20
Meat products	1,841	.53	2,280	.65	3,300	.93	266	.08	308	.09	540	.15
Dairy products	1,639	.67	1,586	.85	1,750	1.27	239	.10	218	.12	240	.17
Canning and preserving	1,741	.61	2,318	.77	3,840	1.06	384	.14	479	.16	820	.23
Grainmill products	913	.66	1,246	.85	1,880	1.20	155	.11	189	.13	290	.19
Bakery products	1,018	.37	1,190	.51	1,250	.61	156	.06	165	.07	230	.11
Confectionery products	643	.78	674	.87	860	1.07	111	.13	118	.15	140	.17
Beverages	1,588	.67	1,966	.86	2,900	1.24	273	.12	296	.13	350	.15
Misc. food preparations	1,786	.99	2,309	1.24	3,380	1.66	319	.18	384	.21	580	.28
Tobacco manufacturing	788	.96	817	1.21	860	1.49	204	.25	192	.29	200	.35
Textile mill products	6,421	.66	7,134	.79	10,370	.98	1,143	.12	1,262	.14	1,960	.19
Knitting mills	1,472	.60	1,554	.66	2,220	.66	208	.08	237	.10	360	.11
Dyeing, finishing textiles	652	.78	781	.99	1,155	1.50	118	.14	131	.17	190	.25
Floor coverings	861	1.51	1,134	1.85	2,080	2.01	151	.26	184	.30	360	.35
Yarn, fabric mills	2,962	.57	3,211	.71	4,345	.95	561	.11	599	.13	890	19
Misc. textile mill products	456	.61	454	.65	570	.69	105	.14	111	.16	160	.19
Apparel, textile products	6,206	.45	7,093	.53	10,750	.69	894	.06	1,058	.08	2,000	.13
Apparel and accessories	5,482	.45	6,203	.54	9,360	.71	805	.07	946	.08	1,780	.13
Misc. fabricated products	724	.43	890	.46	1,390	.59	89	.05	112	.06	220	.09
Paper and allied products	5,885	.83	6,899	.99	11,250	1.42	1,036	.15	1,149	.17	2,100	.27
Pulp, paper, paperboard mills	2,944	1.01	3,320	1.25	5,130	2.01	582	.20	599	.23	1,010	.39
Paperboard containers, boxes	1,033	.46	1,040	.49	1,540	.58	183	.08	191	.09	380	.14
Misc. paper and pulp products	1,908	1.01	2,539	1.16	4,580	1.71	271	.14	359	.16	710	.26

See notes at end of table.

Table B-1. Continued—Industry distribution of computer employment by occupation, 1970, 1978, and projected 1990

Industry	Total, all computer occupations						Computer programmers					
	1970		1978		1990		1970		1978		1990	
	Employment	Percent of industry employment	Employment	Percent of industry employment	Employment	Percent of industry employment	Employment	Percent of industry employment	Employment	Percent of industry employment	Employment	Percent of industry employment
Printing and publishing	12,220	1.05	15,921	1.26	25,740	1.92	2,199	0.19	3,101	0.25	5,590	0.42
Newspaper publishing, printing	2,281	.55	3,223	.70	5,570	1.05	440	.11	552	.12	1,050	.20
Printing, publishing, exc. newspaper	9,939	1.34	12,698	1.59	20,170	2.48	1,759	.24	2,549	.32	4,540	.56
Chemical and allied products	13,734	1.33	18,144	1.68	31,320	2.33	3,193	.31	3,851	.36	6,400	.48
Industrial chemicals	4,389	1.38	5,526	1.70	10,010	2.54	1,317	.41	1,493	.46	2,700	.69
Plastics, synthetics	1,042	1.02	1,361	1.41	2,370	2.18	272	.27	298	.31	410	.38
Synthetic fibers	1,128	1.04	1,425	1.22	2,530	1.40	226	.21	271	.23	520	.29
Drugs and medicines	2,778	1.94	4,436	2.39	7,380	3.57	614	.34	912	.49	1,550	.70
Soaps and cosmetics	2,034	1.63	2,577	1.92	4,040	2.43	345	.28	416	.31	590	.35
Paints and varnishes	1,018	1.49	1,278	1.77	2,000	2.17	127	.19	161	.22	230	.25
Agricultural chemicals	557	1.01	777	1.27	1,220	2.14	124	.23	156	.26	190	.33
Misc. chemicals	798	.72	764	.89	970	.85	168	.15	144	.17	210	.18
Petroleum and coal products	5,141	2.70	6,883	3.30	9,750	5.48	1,280	.67	1,503	.72	1,950	1.10
Petroleum refining	4,807	3.13	6,449	3.92	9,090	7.48	1,250	.81	1,464	.89	1,890	1.56
Misc. petroleum, coal products	334	.91	434	.99	660	1.17	30	.08	39	.09	60	.11
Rubber, misc. plastic products	5,294	.92	6,957	.93	10,760	1.34	1,000	.17	1,231	.16	1,800	.22
Rubber products	3,674	1.28	4,162	1.41	5,750	1.70	760	.26	822	.28	1,010	.30
Misc. plastic products	1,620	.56	2,795	.62	5,010	1.08	240	.08	409	.09	790	.17
Leather products	1,897	.59	1,826	.71	2,040	.95	289	.09	283	.11	310	.14
Leather tanning, finishing	109	.42	106	.47	140	1.02	7	.03	7	.03	10	.07
Footwear, except rubber	1,319	.58	1,217	.71	1,200	.91	223	.10	211	.12	220	.17
All other leather products	469	.68	503	.79	700	1.02	59	.09	65	.10	80	.12
Transportation, other public utilities	48,606	.97	65,505	1.13	107,130	1.69	9,345	.19	12,445	.22	23,000	.36
Transportation, total	20,130	.70	23,966	.73	32,780	.93	3,095	.11	3,894	.12	5,500	.16
Railroads, railway express	8,186	1.33	6,937	1.36	6,225	1.45	768	.12	689	.13	650	.15
Local, interurban transit	540	.14	595	.13	880	.16	60	.02	73	.02	100	.02
Street railways, bus lines	516	.18	558	.16	845	.20	56	.02	65	.02	90	.02
Taxicab service	24	.03	37	.03	35	.03	4	—	8	.01	10	.01
Trucking and warehousing	4,343	.37	5,739	.39	8,035	.52	554	.05	814	.06	1,300	.08
Trucking services	3,829	.36	5,129	.38	7,195	.50	490	.05	730	.05	1,160	.08
Warehousing and storage	514	.58	610	.65	840	.81	64	.07	84	.09	140	.14
Water transportation	1,106	.47	1,293	.53	1,720	.81	258	.11	368	.15	450	.21
Air transportation	4,522	1.31	6,822	1.63	11,080	2.10	1,155	.34	1,486	.36	2,100	.40
Pipelines	367	2.17	537	2.81	850	5.32	113	.67	147	.77	160	1.00
Transportation services	1,066	1.00	2,043	1.20	3,990	1.57	187	.17	317	.19	740	.29
Communications, utilities, sanitary services	28,475	1.32	41,539	1.69	74,350	2.65	6,250	.29	8,551	.35	17,500	.62
Communications	16,286	1.51	23,992	1.99	48,525	3.50	3,300	.31	4,628	.38	10,400	.75
Telephone (wire and radio)	14,660	1.62	21,097	2.19	43,450	4.02	2,887	.32	3,985	.41	9,100	.84
Telegraph, misc. comm. services	1,004	2.11	1,931	3.05	3,160	5.17	276	.58	445	.70	850	1.39
Radio broadcasting, TV	622	.48	964	.54	1,825	.75	137	.11	198	.11	450	.18
Utilities, sanitary services	12,190	1.13	17,547	1.39	25,825	1.82	2,950	.27	3,923	.31	7,100	.50
Electric light and power	4,343	1.33	7,080	1.61	10,505	2.54	1,069	.33	1,710	.39	3,400	.81
Electric—gas utilities	3,994	2.04	4,847	2.36	7,210	3.08	832	.42	989	.48	1,700	.73
Gas, steam supply systems	2,854	1.72	3,507	2.11	4,725	2.83	858	.52	975	.59	1,500	.90
Water supply	758	.57	1,060	.69	1,600	.85	141	.11	185	.12	300	.16
Sanitary services	152	.06	950	.33	1,460	.36	28	.01	37	.01	110	.03
Other utilities, n.e.c.	84	1.25	103	1.45	225	2.21	22	.33	27	.38	90	.88
Wholesale and retail trade	93,137	.57	141,665	.89	242,000	.95	13,550	.08	19,409	.09	35,000	.14
Wholesale trade	62,738	1.59	94,614	1.96	164,640	3.08	9,695	.25	13,663	.28	24,000	.45
Wholesale, except misc. wholesale	50,254	1.90	78,236	2.35	140,950	3.77	7,955	.30	11,347	.34	20,100	.54
Motor vehicles and equipment	4,309	1.30	6,441	1.50	9,180	1.76	543	.16	810	.19	1,450	.28
Drugs, chemicals allied products	5,006	2.15	6,250	2.32	8,220	2.82	670	.29	832	.31	1,250	.43
Dry goods and apparel	2,041	1.30	2,444	1.46	3,370	1.75	300	.19	369	.22	450	.23
Food and related products	5,927	1.02	7,767	1.16	10,680	1.49	865	.15	1,155	.17	1,550	.22
Farm products—raw materials	633	.60	1,138	.73	1,620	1.61	118	.11	208	.13	300	.30
Electrical goods	4,766	1.50	6,671	1.78	10,120	2.20	664	.21	908	.24	1,400	.30
Hardware, plumbing	1,762	1.03	2,131	1.02	2,760	1.23	267	.16	378	.18	500	.22
Machinery, equipment, supplies	25,810	3.46	45,394	4.28	98,190	7.99	4,528	.61	6,687	.63	13,200	1.07
Misc. wholesale trade	12,484	.97	16,378	1.10	24,150	1.50	1,740	.13	2,316	.16	3,900	.24
Metals and minerals, n.e.c.	1,362	1.01	1,673	1.19	2,415	1.48	170	.13	200	.14	350	.21
Petroleum products	2,336	1.17	2,527	1.08	3,015	1.26	458	.23	622	.27	1,100	.46
Scrap and waste material	82	.08	155	.12	315	.27	15	.01	26	.02	50	.04
Alcoholic beverages	1,352	1.37	2,042	1.56	2,760	2.22	118	.12	183	.14	250	.20
Paper and its products	1,343	1.01	1,601	1.22	2,270	1.40	146	.11	168	.13	200	.12
Lumber, construction materials	708	.44	955	.54	1,440	.67	92	.06	110	.06	150	.07
Wholesale trade, n.e.c.	5,299	1.14	7,425	1.37	11,940	2.01	741	.16	1,007	.19	1,800	.30
Retail trade	30,399	.24	47,051	.30	77,360	.38	3,855	.03	5,746	.04	1,000	.05
Building materials	937	.16	1,311	.18	1,940	.24	149	.03	215	.03	300	.04
Lumber, building materials	549	.15	921	.19	1,450	.30	87	.02	139	.03	200	.04
Hardware and farm equipment	388	.17	390	.16	490	.15	62	.03	76	.03	100	.03
General mechandise, total	15,537	.61	22,727	.77	37,420	.87	1,956	.08	2,819	.10	6,200	.14
Department, mail order	11,845	.76	18,570	.96	31,615	1.06	1,498	.10	2,327	.12	5,550	.19
Limited price stores	1,001	.32	1,065	.38	1,490	.45	95	.03	106	.04	150	.05
Vending machine operators	273	.40	324	.43	505	.39	25	.04	25	.03	50	.04
Direct selling	724	.22	782	.22	850	.25	168	.05	165	.05	200	.06
Misc. merchandise stores	1,694	.56	1,984	.66	2,960	.60	170	.06	196	.07	250	.05
Food and dairy stores	3,996	.20	6,553	.28	11,500	.39	476	.02	733	.03	1,350	.05
Grocery stores	3,676	.22	5,975	.30	10,400	.40	452	.03	698	.03	1,290	.05
Dairy product stores	124	.34	219	.49	350	.84	12	.03	19	.04	30	.07
Retail bakeries	115	.10	231	.17	530	.35	8	.01	13	.01	20	.01
Food stores, n.e.c.	81	.07	128	.09	220	.15	4	—	3	—	10	.01
Auto dealers, gas stations	1,306	.07	2,034	.10	3,100	.14	103	.01	155	.01	200	.01
Motor vehicle dealers	752	.10	1,064	.12	1,585	.16	72	.01	100	.01	125	.01
Tire, battery, accessory stores	515	.28	915	.35	1,460	.40	31	.02	55	.02	75	.02
Apparel and accessories	2,220	.29	3,303	.36	5,080	.45	208	.03	292	.03	450	.04
Apparel, accessory stores	1,643	.27	2,481	.33	3,840	.43	135	.02	181	.02	300	.03
Shoe stores	577	.38	822	.47	1,240	.53	73	.05	111	.06	150	.06
Furniture and appliances	1,421	.26	2,237	.33	3,940	.49	254	.05	401	.06	750	.09
Home furnishing stores	658	.19	943	.23	1,620	.32	86	.02	123	.03	240	.05
Appliances, TV, radio stores	763	.36	1,294	.48	2,320	.76	168	.08	278	.10	510	.17
Eating and drinking places	1,108	.04	2,736	.06	4,310	.08	103	—	166	—	250	—

See notes at end of table.

Table B-1. Continued—Industry distribution of computer employment by occupation, 1970, 1978, and projected 1990

Industry	Total, all computer occupations						Computer programmers					
	1970		1978		1990		1970		1978		1990	
	Employment	Percent of industry employment	Employment	Percent of industry employment	Employment	Percent of industry employment	Employment	Percent of industry employment	Employment	Percent of industry employment	Employment	Percent of industry employment
Misc. retail trade stores	3,874	0.26	6,150	0.33	10,070	0.42	606	0.04	965	0.05	1,500	0.06
Drug stores	1,028	.22	1,338	.27	2,050	.31	174	.04	245	.05	400	.06
Liquor stores	103	.08	147	.09	210	.10	12	.01	21	.01	40	.02
Farm, garden supply stores	235	.20	447	.27	720	.39	49	.04	86	.05	120	.07
Jewelry stores	250	.24	401	.30	680	.42	27	.03	47	.03	90	.06
Fuel and ice dealers	577	.50	657	.60	895	.36	50	.04	52	.05	50	.05
Retail florists	12	.01	16	.01	20	.01	–	–	–	–	–	–
Misc. retail trade stores	1,669	.36	3,144	46	5,495	.62	294	.06	514	.07	800	.09
Finance, insurance, real estate	103,858	2.72	152,498	3.03	266,900	4.11	20,430	.53	26,300	.52	51,000	.79
Finance, total	52,796	3.27	90,813	4.23	172,890	5.66	9,039	.56	13,440	.63	28,300	.93
Banking	39,878	4.02	69,366	5.20	135,990	7.02	6,656	.67	9,915	.74	22,100	1.14
Credit agencies	6,306	1.76	12,138	2.38	20,700	2.68	1,153	.32	1,997	.39	4,200	.54
Stock brokers, investment	6,612	2.49	9,309	3.09	15,200	4.41	1,230	.46	1,528	.51	2,000	.58
Insurance	49,211	3.64	58,871	3.66	89,780	4.58	11,078	.82	12,388	.77	22,000	1.12
Real estate	1,851	.22	2,814	.22	4,230	.29	313	.04	472	.04	700	.05
Services, total	184,994	.90	343,759	1.26	719,900	2.06	50,531	.24	84,366	.31	204,000	.58
Hotels and lodging places	688	07	1,171	.09	2,220	.12	99	.01	152	.01	270	.01
Hotels and motels	586	.08	1,110	.12	2,155	.16	99	.01	152	.02	270	.02
Lodging places, except hotels	102	.03	61	.02	65	.01	–	–	–	–	–	–
Other personal services	809	.06	587	.04	610	.04	51	–	42	–	40	–
Laundry, cleaning	804	.13	578	.13	610	.20	51	.01	42	.01	40	.01
Misc. business services	90,262	5.52	169,570	6.36	376,610	9.02	26,071	1.59	44,023	1.65	112,300	2.69
Advertising	854	.66	1,063	.71	1,560	1.05	214	.17	258	.17	360	.24
Business management services	6,849	3.83	13,062	4.72	28,050	6.08	1,938	1.09	3,399	1.23	8,600	1.86
Commercial R&D	4,029	4.60	8,331	6.15	20,930	9.23	1,797	2.05	3,297	2.43	8,800	3.88
Computer programming	58,661	52.28	110,361	57.45	255,580	70.99	19,366	17.26	31,799	16.55	79,660	22.13
Detective and protective	407	.29	937	.33	2,180	.46	82	.06	181	.06	480	.10
Employment, temporary help	6,725	3.12	9,412	2.44	10,410	1.66	307	.14	640	.17	1,600	.25
Services to buildings	36	.01	68	.01	150	.02	–	–	–	–	–	–
Other misc. services	12,701	2.68	26,336	3.36	57,750	5.40	2,367	.50	4,449	.57	12,800	1.20
Automobile repair services	780	.16	1,232	.17	2,190	.25	105	.02	151	.02	310	.03
Auto repair	39	.01	166	.03	390	.07	–	–	–	–	–	–
Auto services, except repair	741	.44	1,066	.49	1,800	.60	105	.06	151	.07	310	.10
Other repair services	2,128	.67	4,244	.94	12,700	2.57	–	–	–	–	–	–
Electrical repair shops	993	.79	1,339	1.02	4,200	2.29	–	–	–	–	–	–
Other repair services	1,135	.59	2,905	.91	8,500	2.74	–	–	–	–	–	–
Motion pictures, theaters	862	.36	827	.40	1,070	.35	189	.08	181	.09	210	.07
Misc. entertainment	291	.07	741	.10	1,280	.15	44	.01	121	.02	340	.04
Medical, other health	13,554	.29	26,371	.39	57,970	.53	2,495	.05	4,642	.07	13,500	.12
Hospitals	11,538	.39	21,232	.54	48,430	.33	2,016	.07	3,499	.09	10,710	.18
Convalescent institutions	156	.03	501	.06	1,790	.08	27	.01	66	.01	390	.02
Health services, n.e.c.	1,860	.68	4,838	.67	8,750	.94	452	.16	1,077	.16	2,400	.26
Legal services	201	.05	365	.06	690	.09	30	.01	64	.01	160	.02
Educational services	33,927	.56	58,066	.77	102,840	1.28	11,785	.20	17,713	.24	33,000	.41
Elementary, secondary	4,461	.11	7,596	.15	11,430	.22	1,048	.03	1,620	.03	3,000	.06
Colleges and universities	26,507	1.68	45,195	2.24	80,720	3.58	10,047	.64	14,887	.74	27,500	1.22
Libraries	160	.20	435	.42	1,270	.84	54	.07	124	.12	400	.26
Educational services, n.e.c.	2,799	1.12	4,840	1.31	9,420	1.91	636	.25	1,082	.29	2,100	.43
Museums, art galleries, zoos	47	.16	119	.23	320	.35	16	.06	30	.06	70	.08
Nonprofit organizations	6,372	.45	9,616	.50	15,350	.62	950	.07	1,495	.08	2,800	.11
Religious organizations	587	.10	924	.13	1,070	.14	–	–	–	–	–	–
Welfare services	2,837	.66	4,191	.65	6,670	.71	423	.10	686	.11	1,200	.13
Nonprofit membership organizations	2,928	.77	4,478	.91	7,590	1.25	527	.14	809	.16	1,600	.26
Other professional, related services	35,073	4.26	70,850	5.47	146,050	8.94	8,696	1.06	15,752	1.22	41,000	2.51
Engineering and architectural services	3,470	1.09	8,169	1.66	20,210	3.22	1,317	.41	2,462	.50	8,100	1.29
Misc. professional services	5,002	2.42	9,943	2.76	23,840	5.51	1,969	.95	3,449	.96	10,900	2.52
Government, total	82,343	1.94	116,695	2.31	207,500	3.49	18,260	.43	24,722	.49	46,600	.78
Federal public administration	52,551	2.32	68,319	3.01	101,675	4.26	12,785	.57	15,277	.67	20,600	86
Postal service	712	.10	1,637	.24	3,800	.57	143	.02	278	.04	600	.09
Other Federal public administration	51,869	3.35	66,682	4.19	97,875	5.68	12,642	.82	14,999	.94	20,000	1.16
State public administration	18,504	3.00	30,099	3.33	63,025	5.56	3,185	.52	5,629	.62	14,000	1.24
Local public administration	11,288	.82	18,277	.99	42,800	1.76	2,290	.17	3,816	.21	12,000	.49

See notes at end of table.

Table B-1. Continued—Industry distribution of computer employment by occupation, 1970, 1978, and projected 1990

Industry	Computer systems analysts						Computer and peripheral equipment operators					
	1970		1978		1990		1970		1978		1990	
	Employ-ment	Percent of industry employ-ment	Employ-ment	Percent of industry employ-ment	Employ-ment	Percent of industry employ-ment	Employ-ment	Percent of industry employ-ment	Employ-ment	Percent of industry employ-ment	Employ-ment	Percent of industry employ-ment
Total, all industries	102,697	0.13	181,998	0.20	400	.35	149,995	0.19	392,993	0.42	850,000	0.75
Agriculture, forestry, fisheries	18	–	45	–	200	.01	122	–	337	.01	625	.02
Agriculture	8	–	17	–	75	--	89	–	216	.01	380	.01
Agricultural production	–	–	–	–	10	--	35	–	61	–	120	.01
Services, except horticulture	8	–	17	.01	50	.02	47	.03	136	.06	220	.07
Horticultural services	–	–	–	–	15	.01	7	–	19	.01	40	.02
Forestry	10	.02	28	.04	85	.12	26	.05	97	.12	190	.27
Fisheries	–	–	–	–	40	.06	7	.02	24	.03	55	.09
Mining	969	.15	2,354	.26	5,000	.47	1,634	.26	5,397	.61	11,650	1.10
Metal mining	80	.09	129	.14	250	.22	84	.09	182	.19	400	.35
Coal mining	13	.01	35	.02	100	.03	60	.04	208	.10	450	.13
Crude petroleum and natural gas	840	.30	2,132	.47	4,500	.92	1,361	.49	4,707	1.04	10,150	2.07
Nonmetallic mining, quarrying	36	.04	58	.05	150	.13	129	.11	300	.24	650	.56
Construction	839	.02	1,423	.03	3,000	.04	1,432	.03	3,641	.06	7,725	.11
General building contractors	81	.01	164	.01	400	.02	155	.01	409	.03	1,100	.06
General contractors, exc. building	648	.05	1,106	.07	2,350	.12	1,121	.08	2,576	.17	5,300	.28
Special trade contractors	110	–	153	–	250	.01	156	.01	656	.02	1,325	.04
Manufacturing	38,002	.20	61,915	.30	119,500	.51	45,967	.23	103,093	.50	215,000	.91
Durable goods	31,103	.27	50,977	.41	99,500	.68	30,262	.27	68,915	.56	145,000	1.00
Ordnance	2,138	.72	1,951	1.14	3,100	1.79	1,631	.55	1,995	1.16	2,700	1.56
Lumber and wood products	179	.03	293	.04	550	.07	286	.05	658	.10	1,450	.20
Logging	–	–	–	–	–	–	14	.01	37	.03	80	.08
Sawmills, planing mills	130	.03	211	.05	370	.08	136	.04	311	.07	670	.14
Misc. wood products	49	.04	82	.06	180	.11	136	.11	310	.24	700	.41
Furniture and fixtures	142	.03	242	.05	420	.06	500	.11	1,187	.23	2,370	.35
Stone, clay, and glass products	431	.07	705	.10	1,360	.19	959	.15	2,152	.31	4,400	.62
Glass and glass products	158	.08	249	.13	480	.22	231	.12	523	.26	1,150	.52
Cement, concrete, plaster	150	.07	238	.10	440	.17	336	.15	747	.30	1,500	.58
Structural clay products	10	.02	14	.03	20	.06	37	.06	68	.13	120	.38
Pottery and related products	11	.03	18	.04	30	.07	61	.14	152	.32	380	.90
Misc. nonmetallic stone	102	.08	186	.12	390	.25	294	.22	662	.44	1,250	.81
Primary metal industries	1,214	.09	1,878	.15	2,900	.22	2,417	.19	5,061	.40	11,000	.82
Blast furnaces, steel works	590	.11	803	.17	1,170	.24	1,165	.21	2,216	.46	4,500	.94
Other primary steel	137	.04	242	.07	380	.09	484	.13	1,062	.29	2,300	.54
Primary aluminum	276	.18	508	.29	870	.48	306	.20	766	.43	1,600	.88
Other primary nonferrous	211	.09	325	.14	480	.19	462	.21	1,017	.44	2,600	1.00
Fabricated metal products	904	.06	1,620	.10	2,700	.14	2,258	.16	5,520	.36	12,080	.65
Cutlery, other hardware	179	.11	333	.19	610	.27	274	.18	686	.38	1,500	.66
Fabricated metal products	270	.06	508	.10	910	.13	591	.14	1,499	.30	3,380	.49
Screw machine products	77	.08	124	.11	190	.17	175	.17	409	.38	850	.75
Metal stamping	88	.04	156	.06	280	.10	426	.18	1,010	.41	2,250	.77
Misc. metal products	290	.06	499	.09	710	.13	792	.17	1,916	.37	4,100	.75
Machinery, except electrical	13,131	.67	24,490	1.06	54,500	1.83	7,674	.39	20,163	.87	51,500	1.73
Engines and turbines	243	.22	447	.34	830	.58	280	.25	736	.56	1,900	1.33
Farm machinery, equipment	215	.17	362	.24	550	.31	395	.31	974	.65	2,500	1.39
Construction machinery	672	.23	1,283	.35	2,500	.54	679	.23	1,822	.49	4,100	.88
Metalworking machinery	300	.09	515	.15	1,020	.23	713	.22	1,764	.51	3,800	.87
Office, accounting machinery	1,005	1.19	1,254	1.74	1,600	2.43	621	.68	1,049	1.46	1,800	2.73
Electronic computing equipment	9,864	5.25	19,286	7.20	45,400	9.66	3,198	1.70	9,283	3.46	27,000	5.74
Machinery, n.e.c.	752	.09	1,343	.14	2,600	.21	1,788	.21	4,535	.47	10,400	.84
Electrical machinery	5,977	.31	9,362	.45	16,870	.67	6,641	.35	14,525	.71	31,000	1.24
Household appliances	274	.15	411	.23	720	.34	392	.21	829	.45	2,100	.99
Radio, TV, communications equipment	2,694	.43	3,804	.63	6,100	.93	2,971	.47	5,591	.93	9,900	1.51
Electrical machinery, n.e.c.	3,009	.27	5,147	.40	10,050	.62	3,278	.30	8,105	.64	19,000	1.17
Transportation equipment	5,285	.28	7,504	.36	11,800	.50	5,668	.30	11,919	.58	20,800	.88
Motor vehicle equipment	1,204	.15	2,219	.23	4,400	.38	1,937	.24	5,054	.51	9,590	.84
Aircraft and parts	3,673	.56	4,655	.80	6,380	1.24	3,115	.47	5,477	.93	8,300	1.62
Ship, boat building, repair	326	.12	452	.16	690	.22	483	.18	972	.34	1,900	.60
Railroad equipment	63	.13	130	.21	210	.33	76	.15	203	.33	450	.70
Mobile dwellings	13	.02	35	.03	90	.03	25	.03	88	.08	250	.09
Cycles, misc. transportation equipment	5	.02	13	.03	30	.05	32	.13	125	.29	310	.47
Professional and scientific instruments	1,408	.31	2,490	.44	4,510	.66	1,518	.33	3,965	.70	7,400	1.08
Scientific instruments	623	.35	1,031	.53	1,600	.82	536	.30	1,255	.64	2,160	1.10
Optical, health service supplies	210	.15	465	.23	970	.36	335	.25	1,087	.53	2,100	.79
Photo equipment and supplies	554	.50	966	.74	1,900	1.03	615	.56	1,546	1.18	3,000	1.63
Watches and clock devices	21	.07	28	.09	40	.11	32	.10	77	.25	140	.39
Misc. manufacturing	295	.06	442	.09	790	.16	710	.16	1,770	.38	3,000	.60
Nondurable goods	6,899	.08	10,938	.13	20,000	.22	15,705	.19	34,718	.41	70,000	.77
Food and kindred products	877	.05	1,279	.07	2,250	.13	2,851	.16	6,177	.36	11,900	.69
Meat products	72	.02	106	.03	180	.05	447	.13	1,055	.30	2,050	.58
Dairy products	158	.07	195	.11	270	.20	382	.16	663	.36	1,020	.74
Canning and preserving	143	.05	207	.06	410	.11	455	.16	1,006	.34	2,100	.58
Grainmill products	79	.05	128	.08	230	.15	279	.20	637	.44	1,200	.77
Bakery products	27	.01	54	.02	90	.04	281	.10	599	.26	750	.37
Confectionery products	45	.06	64	.08	100	.12	137	.17	276	.36	510	.64
Beverages	119	.05	163	.07	260	.11	471	.20	1,012	.44	2,040	.87
Misc. food preparations	234	.13	362	.19	580	.28	399	.22	929	.50	1,800	.88
Tobacco manufacturing	68	.08	87	.13	130	.23	209	.26	357	.53	430	.74
Textile mill products	509	.06	748	.08	1,410	.13	1,284	.13	2,656	.30	5,500	.52
Knitting mills	68	.03	96	.04	190	.06	226	.09	483	.20	1,250	.37
Dyeing, finishing textiles	47	.06	77	.10	130	.17	182	.22	369	.47	700	.91
Floor coverings	68	.12	104	.17	220	.21	236	.41	545	.89	1,300	1.26
Yarn, fabric mills	285	.06	403	.09	740	.16	609	.12	1,196	.26	2,100	.46
Misc. textile mill products	41	.05	68	.10	130	.16	31	.04	63	.09	150	.18
Apparel, textile products	386	.03	589	.04	1,090	.07	1,146	.08	2,626	.20	5,900	.38
Apparel and accessories	344	.03	509	.04	930	.07	1,016	.08	2,286	.20	5,150	.39
Misc. fabricated products	42	.02	80	.04	160	.07	130	.08	340	.17	750	.32
Paper and allied products	643	.09	975	.14	1,760	.22	1,335	.19	2,716	.39	5,800	.73
Pulp, paper, paperboard mills	360	.12	482	.18	780	.30	765	.26	1,443	.54	2,900	1.13
Paperboard containers, boxes	67	.03	104	.05	220	.08	200	.09	386	.18	700	.26
Misc. paper and pulp products	216	.12	389	.18	760	.28	370	.20	887	.41	2,200	.82

See notes at end of table.

Table B-1. Continued—Industry distribution of computer employment by occupation, 1970, 1978, and projected 1990

Industry	Computer systems analysts						Computer and peripheral equipment operators					
	1970		1978		1990		1970		1978		1990	
	Employment	Percent of industry employment	Employment	Percent of industry employment	Employment	Percent of industry employment	Employment	Percent of industry employment	Employment	Percent of industry employment	Employment	Percent of industry employment
Printing and publishing	918	0.08	1,694	0.13	3,350	0.25	3,029	0.26	6,756	0.54	13,900	1.04
Newspaper publishing, printing	109	.02	147	.03	280	.05	778	.19	1,781	.39	3,600	.68
Printing, publishing, exc. newspaper	809	.10	1,547	.19	3,070	.38	2,251	.30	4,975	.62	10,300	1.27
Chemical and allied products	2,053	.20	3,333	.31	6,610	.50	3,076	.30	6,737	.62	14,900	1.12
Industrial chemicals	700	.22	1,044	.32	2,140	.54	943	.30	1,934	.59	4,490	1.14
Plastics, synthetics	139	.14	234	.24	420	.39	313	.31	610	.63	1,390	1.28
Synthetic fibers	165	.16	277	.23	580	.32	209	.19	473	.40	1,130	.62
Drugs and medicines	609	.43	1,137	.62	2,250	1.02	546	.38	1,479	.80	3,300	1.50
Soaps and cosmetics	212	.17	320	.24	610	.37	448	.36	1,002	.75	2,200	1.32
Paints and varnishes	85	.13	139	.19	270	.29	247	.36	554	.77	1,200	1.30
Agricultural chemicals	49	.09	80	.13	150	.26	157	.29	363	.60	740	1.30
Misc. chemicals	104	.08	102	.12	190	.17	213	.19	322	.37	450	.40
Petroleum and coal products	919	.49	1,373	.66	1,950	1.10	1,149	.60	2,596	1.25	4,900	2.76
Petroleum refining	884	.57	1,312	.80	1,830	1.51	1,094	.71	2,444	1.49	4,520	3.72
Misc. petroleum, coal products	35	.09	61	.14	120	.21	55	.15	152	.35	380	.68
Rubber, misc. plastic products	403	.07	704	.09	1,330	.17	1,248	.22	2,860	.38	6,100	.76
Rubber products	282	.10	402	.14	710	.21	869	.30	1,656	.56	3,300	.97
Misc. plastic products	121	.04	302	.07	620	.13	379	.13	1,204	.27	2,800	.60
Leather products	123	.04	156	.06	250	.12	378	.12	697	.27	1,100	.51
Leather tanning, finishing	–	–	–	–	–	–	28	.11	57	.25	100	.73
Footwear, except rubber	59	.02	65	.03	90	.07	257	.11	458	.27	650	.49
All other leather products	64	.09	91	.14	160	.23	93	.13	182	.28	350	.51
Transportation, other public utilities	4,788	.09	8,215	.14	17,700	.28	10,834	.22	26,057	.45	52,300	.83
Transportation, total	1,611	.06	2,642	.08	4,700	.13	4,232	.15	9,256	.28	17,100	.49
Railroads, railway express	457	.08	596	.12	800	.19	1,624	.26	2,619	.51	3,200	.75
Local, interurban transit	35	.01	50	.01	75	.01	130	.03	290	.06	600	.11
Street railways, bus lines	31	.01	41	.01	60	.01	130	.04	290	.08	600	.14
Taxicab service	4	–	9	.01	15	.01	–	–	–	–	–	–
Trucking and warehousing	212	.01	392	.02	725	.05	803	.07	2,143	.15	4,200	.27
Trucking services	188	.01	365	.02	685	.05	688	.06	1,863	.14	3,700	.26
Warehousing and storage	24	.03	27	.03	40	.04	115	.13	280	.30	500	.48
Water transportation	122	.05	205	.08	400	.19	144	.06	296	.12	600	.28
Air transportation	609	.18	1,017	.24	1,800	.34	1,228	.36	2,956	.71	6,000	1.14
Pipelines	39	.23	60	.31	100	.63	94	.56	222	1.16	500	3.13
Transportation services	137	.13	322	.19	800	.31	209	.20	730	.43	2,000	.79
Communications, utilities, sanitary services	3,177	.15	5,573	.22	13,000	.46	6,602	.31	16,801	.68	35,200	1.25
Communications	1,970	.18	3,531	.29	9,000	.65	3,960	.37	9,936	.83	24,1000	1.74
Telephone (wire and radio)	1,726	.19	3,026	.31	8,050	.75	3,558	.39	8,805	.91	22,000	2.04
Telegraph, misc. comm. services	184	.39	379	.60	700	1.15	261	.55	738	1.16	1,200	1.97
Radio broadcasting, TV	60	.05	126	.07	250	.10	141	.11	393	.22	900	.37
Utilities, sanitary services	1,207	.11	2,042	.16	4,000	.28	2,642	.25	6,865	.55	11,100	.78
Electric light and power	382	.12	807	.19	1,900	.45	937	.29	2,525	.57	3,400	.81
Electric-gas utilities	470	.24	693	.34	1,300	.56	785	.40	1,671	.82	3,300	1.42
Gas, steam supply systems	274	.16	390	.24	550	.33	667	.40	1,354	.81	2,200	1.32
Water supply	38	.03	66	.04	100	.05	193	.15	469	.31	900	.48
Sanitary services	35	.01	74	.02	120	.03	37	.01	793	.28	1,200	.30
Other utilities, n.e.c.	8	.12	12	.17	30	.29	23	.34	53	.75	100	.98
Wholesale and retail trade	9,942	.06	18,782	.09	35,000	.14	16,595	.10	44,455	.22	90,000	.35
Wholesale trade	7,871	.20	14,789	.31	27,540	.51	9,666	.25	24,948	.52	49,000	.92
Wholesale, except misc. wholesale	6,856	.26	13,126	.40	25,600	.68	7,526	.28	19,926	.60	38,500	1.03
Motor vehicles and equipment	190	.05	345	.08	580	.11	1,069	.32	2,792	.65	4,800	.92
Drugs, chemicals allied products	236	.10	397	.14	660	.23	1,088	.47	2,599	.97	4,650	1.59
Dry goods and apparel	157	.10	257	.16	410	.21	394	.25	881	.53	1,700	.88
Food and related products	274	.05	486	.08	760	.11	1,381	.24	3,314	.50	6,300	.88
Farm products—raw materials	45	.04	108	.07	200	.20	135	.13	478	.31	800	.30
Electrical goods	568	.18	992	.26	1,550	.34	888	.28	2,183	.58	4,400	.96
Hardware, plumbing	50	.03	89	.05	140	.06	280	.16	727	.35	1,300	.58
Machinery, equipment, supplies	5,336	.72	10,452	.99	23,140	1.88	2,291	.31	6,952	.66	14,550	1.18
Misc. wholesale trade	1,015	.08	1,663	.11	2,400	.15	2,140	.17	5,022	.34	10,500	.65
Metals and minerals, n.e.c.	166	.13	250	.18	380	.23	231	.17	497	.35	950	.58
Petroleum products	330	.16	565	.24	770	.32	8	–	11	–	15	.01
Scrap and waste material	–	–	–	–	–	–	30	.03	90	.07	235	.20
Alcoholic beverages	33	.03	62	.05	90	.07	270	.27	757	.58	1,500	1.21
Paper and its products	173	.13	265	.20	390	.24	252	.19	527	.40	1,100	.68
Lumber, construction materials	40	.02	60	.03	90	.04	183	.11	430	.24	900	.42
Wholesale trade, n.e.c.	273	.06	461	.08	680	.11	1,166	.25	2,710	.50	5,800	.97
Retail trade	2,071	.01	3,993	.02	7,460	.04	6,929	.06	19,507	.12	41,000	.20
Building materials	48	.01	87	.01	150	.02	204	.03	563	.08	1,100	.14
Lumber, building materials	35	.01	63	.01	110	.02	163	.04	474	.10	910	.19
Hardware and farm equipment	13	.01	24	.01	40	.01	41	.02	89	.04	190	.06
General merchandise, total	1,162	.05	2,138	.08	4,100	.10	3,537	.14	9,363	.32	19,100	.45
Department, mail order	809	.06	1,628	.08	3,360	.11	2,661	.17	7,626	.39	15,720	.53
Limited price stores	98	.03	147	.05	220	.70	205	.07	424	.15	860	.26
Vending machine operators	22	.03	35	.04	50	.04	34	.15	104	.14	280	.21
Direct selling	37	.01	41	.01	50	.01	200	.06	340	.10	440	.13
Misc. merchandise stores	196	.06	287	.09	420	.08	437	.14	867	.29	1,800	.36
Food and dairy stores	184	.01	378	.02	740	.03	1,099	.06	3,006	.13	7,200	.24
Grocery stores	169	.01	343	.02	670	.03	1,007	.06	2,724	.14	6,420	.25
Dairy product stores	5	.01	11	.02	20	.05	26	.07	75	.17	210	.50
Retail bakeries	–	–	–	–	–	–	50	.04	161	.12	460	.30
Food stores, n.e.c.	10	.01	24	.02	50	.03	16	.01	46	.03	110	.07
Auto dealers, gas stations	45	–	73	–	110	–	295	.02	832	.04	1,900	.08
Motor vehicle dealers	18	–	20	–	25	–	176	.02	434	.05	980	.10
Tire, battery, accessory stores	27	.01	53	.02	85	.02	119	.07	398	.15	920	.25
Apparel and accessories	64	.01	144	.01	290	.03	512	.07	1,400	.15	2,900	.26
Apparel, accessory stores	40	.01	98	.01	200	.02	397	.06	1,076	.14	2,220	.25
Shoe stores	24	.01	46	.03	90	.04	115	.08	324	.19	680	.29
Furniture and appliances	85	.01	190	.03	390	.05	278	.05	801	.12	1,800	.22
Home furnishing stores	22	.01	65	.02	150	.03	151	.04	402	.10	900	.18
Appliance, TV, radio stores	63	.03	125	.05	240	.08	127	.06	399	.15	900	.30
Eating and drinking places	100	–	171	–	220	–	286	.01	1,518	.04	3,100	.06

See notes at end of table.

Table B-1. Continued—Industry distribution of computer employment by occupation, 1970, 1978, and projected 1990

Industry	Computer systems analysts						Computer and peripheral equipment operators					
	1970		1978		1990		1970		1978		1990	
	Employment	Percent of industry employment	Employment	Percent of industry employment	Employment	Percent of industry employment	Employment	Percent of industry employment	Employment	Percent of industry employment	Employment	Percent of industry employment
Eating and drinking places	100	–	171	–	220	–	286	0.01	1,518	0.04	3,100	0.06
Misc. retail trade stores	383	.02	812	.05	1,460	.06	718	.05	2,024	.11	3,900	.16
Drug stores	58	.01	95	.02	140	.02	208	.04	530	.11	1,100	.16
Liquor stores	–	–	–	–	–	–	8	.01	40	.02	80	.04
Farm, garden supply stores	6	.01	18	.01	40	.02	58	.05	196	.12	410	.22
Jewelry stores	17	.02	36	.03	70	.04	44	.04	170	.13	380	.24
Fuel and ice dealers	36	.03	51	.05	75	.07	180	.16	352	.32	640	.62
Retail florists	–	–	–	–	–	–	–	–	–	–	–	–
Misc. retail trade stores	266	.06	612	.09	1,135	.13	220	.05	736	.11	1,290	.15
Finance, insurance, real estate	8,352	.22	14,358	.29	30,100	.46	26,229	.69	69,026	1.37	147,500	2.27
Finance, total	3,949	.25	7,846	.36	19,100	.62	16,038	.99	46,527	2.17	103,000	3.37
Banking	2,933	.30	5,957	.40	15,600	.80	12,452	1.26	36,245	2.72	81,000	4.18
Credit agencies	454	.12	990	.19	2,000	.26	1,821	.51	5,978	1.17	11,500	1.49
Stock brokers, investment	562	.21	899	.30	1,500	.43	1,765	.67	4,304	1.43	9,500	2.75
Insurance	4,251	.31	6,204	.38	10,400	.53	9,751	.72	21,374	1.33	42,500	2.17
Real estate	152	.02	308	.02	600	.04	440	.05	1,125	.09	2,000	.14
Services, total	26,240	.13	59,800	.22	147,500	.42	32,498	.16	103,647	.38	236,000	.67
Hotels and lodging places	93	.01	100	.01	170	.01	130	.01	540	.04	1,400	.07
Hotels and motels	42	–	62	–	125	.01	130	.02	540	.06	1,400	.11
Lodging places, except hotels	51	.02	38	.01	45	.01	–	–	–	–	–	–
Other personal services	48	–	52	–	50	–	110	.01	153	.01	190	.01
Laundry, cleaning	48	.01	52	.01	50	.02	110	.02	153	.03	190	.06
Misc. business services	14,768	.90	33,675	1.26	89,420	2.14	13,208	.81	42,133	1.58	99.560	2.39
Advertising	79	.06	131	.09	260	.18	169	.13	382	.25	740	.50
Business management services	1,404	.77	3,156	1.14	6,900	1.50	1,024	.57	3,402	1.73	8,400	1.82
Commercial R&D	958	1.10	2,211	1.63	5,200	2.29	683	.78	2,137	1.58	6,100	2.69
Computer programming	10,888	9.70	24,640	12.83	66,560	18.49	8,903	7.94	27,219	14.17	61,520	17.09
Detective and protective	7	.01	23	.01	90	.02	111	.08	445	.16	1,300	.28
Employment, temporary help	56	.02	154	.04	510	.08	–	–	–	–	–	–
Services to buildings	–	–	–	–	–	–	–	–	–	–	–	–
Other misc. services	1,376	.29	3,360	.43	9,900	.93	2,318	.49	8,548	.109	21,500	2.01
Automobile repair services	109	.02	202	.02	420	.05	157	.03	494	.07	1,100	.12
Auto repair	–	–	–	–	–	–	35	.01	162	.03	390	.07
Auto services, except repair	109	.06	202	.10	420	.14	122	.07	332	.15	710	.24
Other repair services	–	–	–	–	–	–	–	–	–	–	–	–
Electrical repair shops	–	–	–	–	–	–	–	–	–	–	–	–
Other repair services	–	–	–	–	–	–	–	–	–	–	–	–
Motion pictures, theaters	89	.04	93	.04	150	.05	162	07	289	.14	510	.17
Misc. entertainment	5	–	10	–	20	–	69	.02	347	.04	690	.08
Medical, other health	1,345	.02	3,307	.05	8,600	.08	3,174	.07	10,809	.16	28,500	.26
Hospitals	1,014	.04	2,518	.07	7,250	.12	2,866	.10	9,187	.24	24,470	.42
Convalescent institutions	38	.01	124	.01	650	.03	33	.01	209	.03	630	.03
Health services, n.e.c.	293	.10	665	.10	1,700	.18	275	.10	1,413	.21	3,400	.36
Legal services	5	–	10	–	20	–	26	.01	134	.02	360	.05
Educational services	3,579	.06	7,292	.10	15,200	.19	7,701	.13	22,147	.29	44,500	.55
Elementary, secondary	478	.01	1,152	.02	2,600	.05	970	.02	3,002	.08	4,300	.08
Colleges and univeesities	2,720	.17	5,290	.26	10,710	.47	6,205	.39	17,429	.86	35,450	1.57
Libraries	23	.03	66	.06	190	.13	34	.04	205	.20	650	.43
Educational services, n.e.c.	358	.14	784	22	1,700	.34	492	.20	1,511	.41	4,100	.83
Museums, art galleries, zoos	5	.02	14	.03	50	.05	18	.06	66	.13	190	.21
Nonprofit organizations	555	.04	1,087	.06	2,200	.11	1,162	.08	3,247	.17	6,500	.26
Religious organizations	–	–	–	–	–	–	128	.02	375	.05	510	.06
Welfare services	364	.08	706	.11	1,450	.16	453	.11	1,236	.19	2,450	.26
Nonprofit membership organizations	191	.05	381	.08	750	.12	581	.15	1,636	.33	3,540	.59
Other professional, related services	5,639	.68	13,958	1.07	31,200	1.91	6,581	.80	23,288	1.80	52,500	3.21
Engineering and architectural services	761	.24	2,121	.43	4,500	.72	602	.19	2,382	.48	5,900	.94
Accounting, auditing	3,847	1.29	9,387	2.12	22,000	3.67	5,139	1.72	18,380	4.15	39,900	6.65
Misc. professional services	1,031	.50	2,450	.68	4,700	1.09	840	.41	2,526	.70	6,700	1.55
Government, total	13,547	.32	21,914	.43	42,000	.71	14,684	.34	37,340	.74	89,200	1.50
Federal public administration	10,446	.46	15,094	.66	23,500	.99	9,432	.42	20,664	.91	42,000	1.76
Postal service	143	.02	339	.05	1,000	.15	213	.03	754	.11	2,000	.30
Other Federal public administration	10,333	.67	14,755	.93	22,500	1.31	9,219	.59	19,910	1.25	40,000	2.32
State public administration	1,989	.32	4,408	.49	11,000	.97	3,157	.51	10,135	1.12	29,000	2.56
Local public administration	1,112	.08	2,412	.13	7,500	.31	2,095	.15	6,541	.35	18,200	.75

See notes at end of table.

Table B-1. Continued—Industry distribution of computer employment by occupation, 1970, 1978, and projected 1990

Industry	Keypunch operators						Computer service technicians					
	1970		1978		1990		1970		1978		1990	
	Employment	Percent of industry employment	Employment	Percent of industry employment	Employment	Percent of industry employment	Employment	Percent of industry employment	Employment	Percent of industry employment	Employment	Percent of industry employment
Total, all industries	299,996	0.38	272,993	0.29	230,000	0.20	35,999	0.05	63,001	0.07	160,000	0.14
Agriculture, forestry, fisheries	393	.01	423	.01	350	.01	5	–	5	–	10	–
Agriculture	270	.01	254	.01	200	.01	5	–	5	–	10	–
Agricultural production	119	–	100	–	80	–	–	–	–	–	–	–
Services, except horticulture	131	.08	122	.05	100	.03	–	–	–	–	–	–
Horticultural services	20	.01	32	.01	20	.01	5	–	5	–	10	–
Forestry	123	.23	169	.21	150	.21	–	–	–	–	–	–
Fisheries	–	–	–	–	–	–	–	–	–	–	–	–
Mining	1,718	.27	2,093	.24	1,700	.16	41	.01	87	.01	210	.02
Metal mining	198	.21	189	.18	150	.13	6	.01	7	.01	25	.02
Coal mining	75	.05	93	.04	50	.01	–	–	–	–	–	–
Crude petroleum and natural gas	1,307	.47	1,713	.38	1,400	.29	35	.01	80	.02	185	.04
Nonmetallic mining, quarrying	138	.12	118	.10	100	.09	–	–	–	–	–	–
Construction	2,815	.06	2,573	.04	2,100	.03	95	–	95	–	200	–
General building contractors	397	.03	368	.03	300	.02	17	–	16	–	25	–
General contractors, exc. building	1,985	.14	1,775	.11	1,450	.08	23	–	20	–	35	–
Special trade contractors	443	.02	430	.01	350	.01	55	–	59	–	140	–
Manufacturing	83,019	.42	65,518	.32	47,900	.20	10,796	.05	15,914	.08	41,000	.17
Durable goods	50,435	.44	41,743	.34	33,000	.23	10,370	.09	15,349	.12	39,700	.27
Ordnance	1,492	.50	730	.42	400	.23	130	.04	104	.06	200	.12
Lumber and wood products	675	.11	505	.07	350	.05	5	–	4	–	10	–
Logging	32	.63	26	.02	20	.02	–	–	–	–	–	–
Sawmills, planing mills	485	.12	356	.08	240	.05	5	–	4	–	10	–
Misc. wood products	158	.13	123	.09	90	.05	–	–	–	–	–	–
Furniture and fixtures	1,180	.25	1,011	.19	850	.13	27	.01	42	.01	90	.01
Stone, clay, and glass products	1,617	.25	1,225	.18	900	.13	6	–	6	–	10	–
Glass and glass products	565	.31	399	.20	260	.12	6	–	6	–	10	–
Cement, concrete, plaster	459	.21	357	.15	240	.09	–	–	–	–	–	–
Structural clay products	109	.18	69	.13	50	.16	–	–	–	–	–	–
Pottery and related products	97	.22	75	.16	60	.14	–	–	–	–	–	–
Misc. nonmetallic stone	387	.29	325	.21	290	.19	–	–	–	–	–	–
Primary metal industries	5,107	.39	3,910	.31	2,700	.20	103	.01	117	.01	200	.01
Blast furnaces, steel works	2,530	.46	1,802	.37	1,200	.25	69	.01	78	.02	130	.03
Other primary steel	935	.25	687	.19	470	.11	22	.01	30	.01	50	.01
Primary aluminum	607	.39	570	.32	480	.26	6	–	5	–	10	.01
Other primary nonferrous	1,035	.46	851	.37	550	.21	6	–	4	–	10	–
Fabricated metal products	4,846	.35	4,125	.27	3,300	.18	21	–	20	–	40	–
Cutlery, other hardware	944	.62	823	.46	710	.31	–	–	–	–	–	–
Fabricated metal products	1,307	.30	1,097	.22	780	.11	21	–	20	–	40	.01
Screw machine products	493	.47	395	.36	270	.24	–	–	–	–	–	–
Metal stamping	611	.26	569	.23	490	.17	–	–	–	–	–	–
Misc. metal products	1,491	.32	1,241	.24	1,050	.19	–	–	–	–	–	–
Machinery, except electrical	10,337	.52	9,688	.42	8,600	.29	8,079	.41	12,323	.53	33,890	1.14
Engines and turbines	622	.57	592	.45	520	.36	12	.01	19	.01	50	.04
Farm machinery, equipment	946	.74	812	.54	650	.36	19	.01	27	.02	60	.03
Construction machinery	1,616	.55	1,694	.46	1,540	.33	29	.01	64	.02	150	.03
Metalworking machinery	1,221	.38	1,124	.32	960	.22	48	.02	74	.02	140	.03
Office, accounting machinery	794	.87	479	.66	320	.49	1,125	1.24	1,042	1.45	1,350	2.05
Electronic computing equipment	1,639	.87	1,523	.57	1,410	.30	6,698	3.56	10,842	4.05	31,650	6.73
Machinery, n.e.c.	3,499	.41	3,464	.36	3,200	.26	148	.02	255	.03	490	.04
Electrical machinery	11,140	.58	9,305	.45	7,300	.29	1,306	.07	1,837	.09	3,600	.14
Household appliances	875	.47	652	.36	480	.23	10	.01	14	.01	20	.01
Radio, TV, communications equipment	4,548	.72	3,458	.58	2,400	.37	616	.10	782	.13	1,400	.21
Electrical machinery, n.e.c.	5,717	.52	5,195	.41	4,420	.27	680	.06	1,041	.08	2,180	.13
Transportation equipment	9,209	.48	6,973	.34	5,100	.22	393	.02	436	.02	750	.03
Motor vehicle equipment	3,925	.49	3,623	.37	3,100	.27	46	.01	76	.01	130	.01
Aircraft and parts	4,194	.63	2,463	.42	1,350	.26	276	.04	302	.05	520	.10
Ship, boat building, repair	730	.26	516	.18	310	.10	71	.03	58	.02	100	.03
Railroad equipment	212	.42	203	.33	180	.28	–	–	–	–	–	–
Mobile dwellings	59	.07	57	.05	50	.02	–	–	–	–	–	–
Cycles, misc. transportation equipment	89	.35	111	.26	110	.17	–	–	–	–	–	–
Professional and scientific instruments	2,894	.64	2,743	.49	2,400	.35	268	.06	404	.07	800	.12
Scientific instruments	1,001	.56	849	.43	690	.35	192	.11	268	.14	550	.28
Optical, health service supplies	842	.62	1,009	.49	960	.36	38	.03	76	.04	130	.05
Photo equipment and supplies	868	.80	765	.58	680	.36	38	.03	60	.05	120	.07
Watches and clock devices	183	.58	120	.40	90	.25	–	–	–	–	–	–
Misc. manufacturing	1,938	.44	1,528	.33	1,100	.22	32	.01	56	.01	110	.02
Nondurable goods	32,584	.40	23,775	.29	14,900	.16	426	.01	565	.01	1,300	.01
Food and kindred products	5,458	.31	3,851	.23	2,240	.13	80	–	105	.01	240	.01
Meat products	1,049	.30	806	.23	520	.15	7	–	5	–	10	–
Dairy products	851	.35	505	.27	210	.15	9	–	5	–	10	.01
Canning and preserving	729	.26	572	.19	370	.10	30	.01	54	.02	140	.04
Grainmill products	400	.29	292	.20	160	.10	–	–	–	–	–	–
Bakery products	554	.20	372	.16	180	.09	–	–	–	–	–	–
Confectionery products	350	.42	216	28	110	.14	–	–	–	–	–	–
Beverages	707	.30	473	.21	210	.09	18	.01	22	.01	40	.02
Misc. food preparations	818	.45	615	.33	380	.19	16	.01	19	.01	40	.02
Tobacco manufacturing	307	.38	181	.27	100	.17	–	–	–	–	–	–
Textile mill products	3,464	.35	2,448	.27	1,450	.14	21	–	20	–	50	–
Knitting mills	970	.39	738	.31	420	.13	–	–	–	–	–	–
Dyeing, finishing textiles	298	.36	195	.25	110	.14	7	.01	9	.01	25	.03
Floor coverings	406	.71	301	.49	200	.19	–	–	–	–	–	–
Yarn, fabric mills	1,493	.29	1,002	.22	590	.13	14	–	11	–	25	.01
Misc. textile mill products	297	.40	212	.30	130	.16	–	–	–	–	–	–
Apparel, textile products	3,772	.27	2,814	.21	1,750	.11	8	–	6	–	10	–
Apparel and accessories	3,317	.27	2,462	.21	1,500	.11	–	–	–	–	–	–
Misc. fabricated products	455	.27	352	.18	2.50	.11	8	–	6	–	10	–
Paper and allied products	2,711	.38	1,841	.26	1,100	.14	160	.02	218	.03	490	.06
Pulp, paper, paperboard mills	1,232	.42	793	.30	430	.17	5	–	3	–	10	–
Paperboard containers, boxes	583	.26	359	.17	240	.09	–	–	–	–	–	–
Misc. paper and pulp products	896	.47	689	.32	430	.16	155	.08	215	.10	480	.18

See notes at end of table.

Table B-1. Continued—Industry distribution of computer employment by occupation, 1970, 1978, and projected 1990

Industry	Keypunch operators						Computer Service Technicians					
	1970		1978		1990		1970		1978		1990	
	Employment	Percent of industry employment	Employment	Percent of industry employment	Employment	Percent of industry employment	Employment	Percent of industry employment	Employment	Percent of industry employment	Employment	Percent of industry employment
Printing and publishing	5,997	0.52	4,250	0.34	2,600	0.19	77	0.01	120	0.01	300	0.02
Newspaper publishing, printing	930	.22	693	.15	500	.09	24	.01	50	.01	140	.03
Printing, publishing, exc. newspaper	5,067	.68	3,557	.44	2,100	.26	53	.01	70	.01	160	.02
Chemical and allied products	5,369	.52	4,174	.39	3,000	.23	43	–	49	–	110	.01
Industrial chemicals	1,407	.44	1,032	.32	630	.16	22	.01	23	.01	50	.01
Plastics, synthetics	311	.31	211	.22	130	.12	7	.01	8	.01	20	.02
Synthetic fibers	528	.49	404	.35	300	.17	–	–	–	–	–	–
Drugs and medicines	1,009	.71	908	.49	780	.35	–	–	–	–	–	–
Soaps and cosmetics	1,021	.82	828	.62	610	.37	8	.01	11	.01	30	.02
Paints and varnishes	559	.82	424	.59	300	.33	–	–	–	–	–	–
Agricultural chemicals	221	.40	171	.28	130	.23	6	.01	7	.01	10	.02
Misc. chemicals	313	.28	196	.23	120	.11	–	–	–	–	–	–
Petroleum and coal products	1,778	.94	1,388	.67	900	.51	15	.01	23	.01	50	.03
Petroleum refining	1,564	1.02	1,206	.73	800	.66	15	.01	23	.01	50	.04
Misc. petroleum, coal products	214	.58	182	.41	100	.18	–	–	–	–	–	–
Rubber, misc. plastic products	2,628	.45	2,146	.29	1,500	.19	15	–	16	–	30	–
Rubber products	1,758	.61	1,279	.43	720	.21	5	–	3	–	10	–
Misc. plastic products	870	.30	867	.19	780	.17	10	–	13	–	20	–
Leather products	1,100	.34	682	.26	360	.17	7	–	8	–	20	.01
Leather tanning, finishing	74	.28	42	.19	30	.22	–	–	–	–	–	–
Footwear, except rubber	780	.35	483	.28	240	.18	–	–	–	–	–	–
All other leather products	246	.36	157	.25	90	.13	7	.01	8	.01	20	.03
Transportation, other public utilities	23,113	.46	17,972	.31	12,550	.20	526	.01	816	.01	1,580	.02
Transportation, total	11,091	.39	8,039	.24	5,250	.15	101	–	135	–	230	.01
Railroads, railway express	5,304	.86	2,993	.58	1,500	.35	33	.01	40	.01	75	.02
Local, interurban transit	310	.08	178	.04	100	.02	5	–	4	–	5	–
Street railways, bus lines	294	.10	158	.05	90	.02	5	–	4	–	5	–
Taxicab, service	16	.02	20	.02	10	.01	–	–	–	–	–	–
Trucking and warehousing	2,769	.24	2,383	.16	1,800	.12	5	–	7	–	10	–
Trucking services	2,463	.23	2,171	.16	1,650	.11	–	–	–	–	–	–
Warehousing and storage	306	.35	212	.23	150	14	5	.01	7	.01	10	.01
Water transportation	582	.25	424	.17	270	.13	–	–	–	–	–	–
Air transportation	1,479	.43	1,287	.31	1,050	.20	51	.01	76	.02	130	.02
Pipelines	114	.67	100	.52	80	.50	7	.04	8	.04	10	.06
Transportation services	533	.50	674	.40	450	.18	–	–	–	–	–	–
Communications, utilities, sanitary services	12,022	.56	9,933	.40	7,300	.26	425	.02	681	.03	1,350	.05
Communications	6,687	.62	5,284	.44	3,800	.27	369	.03	613	.05	1,225	.09
Telephone (wire and radio)	6,241	.69	4,880	.51	3,440	.32	248	.03	401	.04	950	.09
Telegraph, misc. comm. services	171	.36	173	.27	160	.26	112	.24	196	.31	250	.41
Radio broadcasting, TV	275	.21	231	.13	200	.08	9	.01	16	.01	25	.01
Utilities, sanitary services	5,335	.50	4,649	.37	3,500	.25	56	.01	68	.01	125	.01
Electric light and power	1,915	.59	1,979	.45	1,800	.43	45	.01	59	.01	105	.03
Electric—gas utilities	1,902	97	1,490	.73	900	.39	5	–	4	–	10	–
Gas, steam supply systems	1,049	.63	783	.47	465	.28	6	–	5	–	10	.01
Water supply	386	.29	340	.22	300	.16	–	–	–	–	–	–
Sanitary services	52	.02	46	.02	30	.01	–	–	–	–	–	–
Other utilities, n.e.c.	31	.46	11	.15	5	.05	–	–	–	–	–	–
Wholesale and retail trade	42,579	.26	40,282	.20	36,000	.14	10,471	.06	18,737	.09	46,000	.18
Wholesale trade	25,446	.65	23,253	.48	20,000	.37	10,060	.26	17,961	.37	44,100	.82
Wholesale, except misc. wholesale	18,279	.69	16,549	.50	14,000	.37	9,638	.36	17,288	.52	42,750	1.14
Motor vehicles and equipment	2,507	.75	2,494	.58	2,350	.45	–	–	–	–	–	–
Drugs, chemicals allied products	3,004	1.29	2,415	.90	1,650	.57	8	–	7	–	10	–
Dry goods and apparel	1,190	.76	937	.56	810	.42	–	–	–	–	–	–
Food and related products	3,391	.58	2,796	.42	2,050	.29	16	–	16	–	20	–
Farm products—raw materials	335	.32	344	.22	320	.32	–	–	–	–	–	–
Electrical goods	2,368	.75	2,153	.57	1,800	.39	278	.09	435	.12	970	.21
Hardware, plumbing	1,165	.68	937	.45	820	.37	–	–	–	–	–	–
Machinery, equipment, supplies	4,319	.58	4,473	.42	4,200	.34	9,336	1.25	16,830	.159	43,100	3.51
Misc. wholesale trade	7,167	.55	6,704	.45	6,000	.37	422	.03	673	.05	1,350	.08
Metals and minerals, n.e.c.	773	.58	678	.48	625	.38	22	.02	48	.03	110	.07
Petroleum products	1,528	.76	1,311	.56	1,100	.46	12	.01	18	.01	30	.01
Scrap and waste material	37	.04	39	.03	30	.03	–	–	–	–	–	–
Alcoholic beverages	924	.94	1,028	.79	900	.72	7	.01	12	.01	20	.02
Paper and its products	755	.57	618	.47	550	.34	19	.01	23	.02	30	.02
Lumber, construction materials	393	.24	355	.20	300	.14	–	–	–	–	–	–
Wholesale trade, n.e.c.	2,757	.59	2,675	.49	2,500	.42	362	.08	572	.11	1,160	.19
Retail trade	17,133	.14	17,029	.11	16,000	.08	411	–	776	–	1,900	.01
Building materials	536	.09	446	.06	390	.05	–	–	–	–	–	–
Lumber, building materials	264	.07	245	.05	230	.05	–	–	–	–	–	–
Hardware and farm equipment	272	.12	201	.08	160	.05	–	–	–	–	–	–
General merchandise, total	8,882	.35	8,407	.29	8,020	.19	–	–	–	–	–	–
Department, mail order	6,877	.44	6,989	.36	6,985	.23	–	–	–	–	–	–
Limited price stores	603	.19	388	.14	260	.08	–	–	–	–	–	–
Vending machine operators	192	.28	160	.21	125	.10	–	–	–	–	–	–
Direct selling	319	.10	236	.07	160	.05	–	–	–	–	–	–
Misc. merchandise stores	891	.29	634	.21	490	.10	–	–	–	–	–	–
Food and dairy stores	2,237	.11	2,436	.10	2,210	.07	–	–	–	–	–	–
Grocery stores	2,048	.12	2,210	.11	2,020	.08	–	–	–	–	–	–
Dairy product stores	81	.22	114	.25	90	.22	–	–	–	–	–	–
Retail bakeries	57	.05	57	.04	50	.03	–	–	–	–	–	–
Food stores, n.e.c.	51	.04	55	.04	50	.03	–	–	–	–	–	–
Auto dealers, gas stations	830	.05	944	.05	850	.04	33	–	30	–	40	–
Motor vehicle dealers	463	.06	489	.06	425	.04	23	–	21	–	30	–
Tire, battery, accessory stores	333	.18	404	.15	375	.10	5	–	5	–	5	–
Apparel and accessories	1,436	.19	1,467	.16	1,440	.13	–	–	–	–	–	–
Apparel, accessory stores	1,071	.17	1,126	.15	1,120	.13	–	–	–	–	–	–
Shoe stores	365	.24	341	.20	320	.14	–	–	–	–	–	–
Furniture and appliances	738	.13	724	.11	700	.09	66	.01	121	.02	300	.04
Home furnishing stores	399	.12	353	.09	330	.07	–	–	–	–	–	–
Appliance, TV, radio stores	339	.16	371	.14	370	.12	66	.03	121	.04	300	.10
Eating and drinking places	619	.02	881	.02	740	.01	–	–	–	–	–	–

See notes at end of table.

Table B-1. Continued—Industry distribution of computer employment by occupation, 1970, 1978, and projected 1990

Industry	Keypunch operators						Computer service technicians					
	1970		1978		1990		1970		1978		1990	
	Employment	Percent of industry employment	Employment	Percent of industry employment	Employment	Percent of industry employment	Employment	Percent of industry employment	Employment	Percent of industry employment	Employment	Percent of industry employment
Retail Trade—Continued												
Misc. retail trade stores	1,855	0.13	1,724	0.09	1,650	0.07	312	0.02	625	0.03	1,560	0.07
Drug stores	588	.13	468	.09	410	.06	–	–	–	–	–	–
Liquor stores	83	.07	86	.05	90	.04	–	–	–	–	–	–
Farm, garden supply stores	122	.10	147	.09	150	.08	–	–	–	–	–	–
Jewelry stores	162	.15	148	.11	140	.09	–	–	–	–	–	–
Fuel and ice dealers	305	.26	195	.18	120	.12	6	.01	7	.01	10	.01
Retail florists	12	.01	16	.01	20	.01	–	–	–	–	–	–
Misc. retail trade stores	583	.13	664	.10	720	.08	306	.07	618	.09	1,550	.18
Finance, insurance, real estate	48,564	1.27	42,287	.84	37,000	.57	283	.01	527	.01	1,300	.02
Finance, total	23,592	1.46	22,615	1.05	21,500	.70	178	.01	385	.02	990	.03
Banking	17,678	1.78	16,908	1.27	16,400	.85	159	.02	341	.03	890	.05
Credit agencies	2,878	.80	3,173	.62	3,000	.39	–	–	–	–	–	–
Stock brokers, investment	3,036	1.15	2,534	.84	2,100	.61	19	.01	44	.01	100	.03
Insurance	24,026	1.78	18,763	1.17	14,600	.74	105	.01	142	.01	280	.01
Real estate	946	.11	909	.07	900	.06	–	–	–	–	–	–
Services, total	63,038	.31	70,814	.26	66,400	.19	12,687	.06	25,132	.09	66,000	.19
Hotels and lodging places	363	.04	377	.03	370	.02	3	–	2	–	10	–
Hotels and motels	312	.04	354	.04	350	.03	3	–	2	–	10	–
Lodging places, except hotels	51	.02	23	.01	20	–	–	–	–	–	–	–
Other personal services	595	.04	337	.02	320	.02	5	–	3	–	10	–
Laundry, cleaning	590	.10	328	.07	320	.10	5	–	3	–	10	–
Misc. business services	27,718	1.69	32,490	1.22	30,200	.72	8,497	.52	17,249	.65	45,130	1.08
Advertising	388	.30	289	.19	190	.13	4	–	3	–	10	.01
Business management services	2,149	1.20	2,407	.87	2,350	.51	334	.19	698	.25	1,800	.39
Commercial R&D	511	.58	538	.40	470	.21	80	.09	148	.11	360	.16
Computer programming	12,963	11.55	13,852	7.21	12,900	3.58	6,541	5.83	12,851	6.69	34,940	9.71
Detective and protective	192	.14	257	.09	240	.05	15	.01	31	.01	70	.01
Employment, temporary help	6,362	2.96	8,618	2.23	8,300	1.32	–	–	–	–	–	–
Services to buildings	–	–	–	–	–	–	36	.01	68	.01	150	.02
Other misc. services	5,153	1.09	6,529	.83	5,750	.54	1,487	.31	3,450	.44	7,800	.73
Automobile repair services	409	.08	385	.05	360	.04	–	–	–	–	–	–
Auto repair	4	–	4	–	–	–	–	–	–	–	–	–
Auto services, except repair	405	.24	381	.18	360	.12	–	–	–	–	–	–
Other repair services	–	–	–	–	–	–	2,128	.67	4,244	.94	12,700	2.57
Electrical repair shops	–	–	–	–	–	–	993	.79	1,339	1.02	4,200	2.29
Other repair services	–	–	–	–	–	–	1,135	.59	2,905	.91	8,500	2.74
Motion pictures, theaters	414	.17	259	.13	190	.06	8	–	5	–	10	–
Misc. entertainment	173	.04	283	.03	230	.03	–	–	–	–	–	–
Medical, other health	6,512	.14	7,585	.11	7,300	.07	28	–	28	–	70	–
Hospitals	5,614	.19	6,000	.15	5,930	.10	28	–	28	–	70	–
Convalescent institutions	58	.01	102	.01	120	.01	–	–	–	–	–	–
Health services, n.e.c.	840	.31	1,483	.22	1,250	.13	–	–	–	–	–	–
Legal services	140	.04	157	.03	150	.02	–	–	–	–	–	–
Educational services	10,594	.18	10,532	.14	9,620	.12	268	–	382	.01	520	.01
Elementary, secondary	1,943	.05	1,799	.04	1,510	.03	22	–	23	–	20	–
Colleges and universities	7,344	.47	7,343	.36	6,780	.30	191	.01	246	.01	280	.01
Libraries	49	.06	40	.04	30	.02	–	–	–	–	–	–
Educational services, n.e.c.	1,258	.50	1,350	.37	1,300	.26	55	.02	113	.03	220	.04
Museums, art galleries, zoos	8	.03	9	.02	10	.01	–	–	–	–	–	–
Nonprofit organizations	3,652	.26	3,702	.19	3,700	.15	53	–	85	–	150	.01
Religious organizations	459	.08	549	.08	560	.07	–	–	–	–	–	–
Welfare services	1,591	.37	1,555	.24	1,550	.17	6	–	8	–	20	–
Nonprofit membership organizations	1,582	.41	1,575	.32	1,570	.26	47	.01	77	.02	130	–
Other professional, related services	12,460	1.51	14,718	1.14	13,950	.85	1,697	.21	3,134	.24	7,400	.45
Engineering and architectural services	669	.21	893	.18	820	.13	121	.04	311	.06	890	.14
Accounting, auditing	10,715	3.58	12,451	2.81	11,870	1.98	1,490	.50	2,679	.60	6,230	1.04
Misc. professional services	1,076	.52	1,374	.38	1,260	.29	86	.04	144	.04	280	.06
Government, total	34,757	.82	31,031	.62	26,000	.44	1,095	.03	1,688	.03	3,700	.06
Federal public administration	18,849	.83	15,660	.69	12,000	.50	1,039	.05	1,624	.07	3,575	.15
Postal service	213	.03	266	.04	200	.03	–	–	–	–	–	–
Other Federal public administration	18,636	1.20	15,394	.97	11,800	.68	1,039	.07	1,624	.10	3,575	.21
State public administration	10,161	1.65	9,912	1.10	9,000	.79	12	–	15	–	25	–
Local public administration	5,747	.42	5,459	.30	5,000	.21	44	–	49	–	100	–

n.e.c. = not elsewhere classified.

NOTE: A dash denotes zero or less than 0.005 percent.

Appendix C. Census Occupational Titles

The 1970 Census of Population lists national totals for computer occupations in six categories. The six categories are designated as follows: Computer Programmer, Computer Systems Analysts, Computer Specialists, n.e.c., Computer Peripheral Equipment Operators, Keypunch Operators, and Data Processing Machine Repairers. The BLS industry- occupational matrix has adopted exactly these census computer occupational categories. However, for purposes of this BLS computer study, two of these common census and matrix occupational categories have been combined. Data for computer specialists, n.e.c., are combined with "systems analysts" because the occupational titles that comprise the "computer specialist, n.e.c.," category seem overwhelmingly to involve systems analysis functions. The job titles included in each of these six categories are as follows:

Computer Programmers
- computer programmer
- digital-computer programmer
- electronic data programmer
- programmer, computer
- Univac-programmer

Computer Systems Analysts
- computer analyst
- computer-systems planning
- computing-systems analyst
- data-processing-systems analyst
- digital-computer-systems analyst
- engineer, systems
- health-systems analyst, computer
- manager, computer programming
- systems analyst, computer systems
- systems analyst, data processing

Computer Specialists, n.e.c.
- computer scientist
- data-processing systems-project planner
- engineer, computer application
- methods analyst, computer
- software specialist

Computer and Peripheral Equipment Operators
- card-tape-converter operator
- computer-console operator
- computer operator
- computing-machine operator
- console operator, clerical
- digital-computer operator
- high-speed-printer operator
- K.S.T. operator
- key station terminal operator
- peripheral-equipment operator
- tape-to-card-converter operator

Keypunch Operators
- card puncher
- card-punching-machine operator
- encoder
- encoder clerk
- I.B.M. machine operator
- I.B.M. operator
- I.B.M. puncher
- I.B.M. supervisor
- I.B.M. verifier
- key puncher
- keypunch operator
- punch-card operator
- punch operator, office machine
- verifying machine operator

Data Processing Machine Repairers
- computer's service man—
  data-processing-machine rental
- data-processing-machine serviceman
- engineer, customer's
- I.B.M. installer
- mechanic:
  - computing systems
  - data processing
  - electronic computer
  - I.B.M. machine

Appendix D. Glossary of Computer Terms

ADP—Automatic data processing.

ALGOL—A higher level programming language used for scientific applications.

Alphanumeric—A set of characters that includes letters, numbers, and special symbols such as punctuation or mathematical notations.

Analog computer—A computer that operates on data represented by measurable physical quantities (speed, temperature, voltage, etc).

Applications programming—Development of programs to meet specific user needs, such as inventory control, payroll, and reservations systems.

Assembler—A computer program that converts the user's instructions written in alphanumerics into a form that the machine can understand.

Automation—The development and application of methods of making a process self-moving or self-controlling.

Auxiliary storage—Any device that supplements the main storage area of a computer.

BASIC (Beginners All-Purpose Symbolic Instruction Code)—A programming language that is relatively easy to learn and can be used for a variety of applications.

Batch processing—A method that uses one program to process accumulations (batches) of similar data.

Binary—A numbering system based on 2's rather than 10's. Only the digits 0 and 1 are used.

Bit—A binary digit (0 or 1).

Byte—A sequence of eight binary digits usually operated upon as a unit.

Canned (packaged) programs—Programs prepared for users in machine-readable form by vendors or software firms to meet specific applications.

Card punch—A machine that encodes data onto tabulating cards in patterns of round or rectangular holes. Card punches may be activated by computer or from a keyboard.

Card reader—A machine that transcribes data from punched cards to main computer storage or auxiliary storage devices.

Centralized data processing—Data processing organization in which the user places all computing power at one site.

Character—One of a set of elements that may be arranged in ordered groups to express information. Each character has two forms: 1) A form that can be read by humans—the graphic, including the decimal digits 0-9, the letters A-Z, punctuation marks, and other formatting and control symbols; 2) a form that can be read by computers—the code, consisting of a group of binary bits.

COBOL (Common Business Oriented Language)—A higher level programming language designed for business applications.

Coding—Preparing a set of computer instructions from a detailed flow chart to perform a given action or solve a given problem.

COM (Computer Output on Microfilm)—An auxiliary computer device that produces microfilm records from computer-generated data.

Compiler—A computer program that converts a higher level language into a machine language program.

Computer—A device capable of accepting a series of logical operations, applying prescribed processes to the sequence, and supplying the results of these processes.

Computer, off-line—A computer not actively monitoring or controlling a process.

Computer, on-line—A computer actively monitoring or controlling a process.

Console—The part of a computer used for manual control and observation of the computer system.

Core storage—The main storage area of a computer containing arrays of magnetic cores, which hold instructions and/or data to be processed.

CPU (Central processing unit)—That portion of a computer containing the arithmetic, logic, control, and, in some cases, main storage devices.

CRT (Cathode ray tube)—A device similar to a television screen upon which data can be stored or displayed.

Data—Basic elements of information—facts, numbers, letters, symbols—that can be processed by a computer.

Data collection—The act of bringing data from one or more locations to a central location.

Data communications—Movement of data from one point to another by electrical transmission systems.

Data processing—A series of planned actions and operations upon data to achieve a desired result.

DDP (Distributed data processing)—Data processing organization that gives computing power to the person who can immediately and most efficiently use the information.

Debugging—The process of determining the correctness of a computer routine, locating any errors, and correcting them. Also, the detection and correction of malfunctions in the computer itself.

Digital computer—A computer that solves problems by using coded numbers to express all quantities and variables.

Downtime—The time interval during which a device is not working properly.

EDP (Electronic Data Processing)—Equipment that processes data by electronic means; e.g., analog or digital computers.

EFTS (Electronic Funds Transfer System)—Method of handling monetary transactions, such as bank deposits and bill payments, using computers and other electronic equipment instead of paper.

External memory—A storage facility or device, such as magnetic tape, which is not an integral part of a computer.

File—A collection of related records; e.g., a complete set of invoices in an invoice file.

Firmware—A set of functions built into the computer hardware that would otherwise be handled by software or special purpose logic.

FORTRAN (Formula translator)—a higher level programming language designed for mathematical, scientific, and engineering applications.

General-purpose computers—Computers that are primarily character or byte-oriented and programmed in higher level languages.

Generation—A stage of technological advance in computers. First-generation computers were characterized by their use of vacuum tubes; second generation, by transistors; and third generation, by integrated circuits.

Hard copy—Printed copy of machine output; e.g., reports, tables, listings, documents, and other business forms.

Hardware—The actual equipment used in a computer system, including peripheral equipment such as printers and tape drives, as well as the computer itself.

High speed printer—Computer output printer that prints all of the characters on a line simultaneously.

Higher level language—Programming language designed for a specific range of applications and relative ease of use.

Input—Information representing data to be processed and instructions to control processing, which is moved into the internal storage of a data processing system.

Instruction—A coded statement or command that causes a data processing system to carry out an operation.

Interface—The interconnection between two pieces of hardware or two systems that have different functions.

Internal storage—Memory devices, such as magnetic cores, forming an integral physical part of a computer and directly controlled by the central processing unit.

Key-to-disk, key-to-tape systems—Systems for entering data directly onto a disk or tape by typing at a keyboard.

Keypunch—A keyboard-operated device that punches holes in a card to represent data.

Key verifier—A device, similar to the keypunch, used to make sure that data have been correctly punched into cards.

Line printer—A printing device that accepts information directly from a computer and prints one line at a time.

Machine language—Language that can be understood and interpreted directly by a computer.

Magnetic disk—A flat, circular plate with a surface that can be magnetized to store data.

Magnetic ink—Ink that contains particles of iron oxide, which can be detected (read) by machine sensors.

Magnetic tape—Tape with a ferrous oxide surface upon which data can be stored.

Main storage—The general-purpose storage area of a computer (same as internal storage).

Memory—A device or medium used to store information in a form that can be understood by the computer hardware.

MICR (Magnetic Ink Character Recognition)—Machine recognition of characters printed on a document with magnetic ink.

Microfiche—Sheet of film used for displaying computer output using a small amount of storage space.

Microfilm—Photographic filmstrip used for retaining records of printed document while utilizing a small amount of storage space.

Minicomputer—Small, general-purpose computers that are part of a family that has at least one product in the $2,000-$25,000 price range and comes with at least 4K

RAM. Size classes are Supermini, Traditional Mini, and Micro-mini.

Multiprocessor—A computer system incorporating multiple arithmetic and logic units for simultaneous use.

Multiprogramming—A technique for handling numerous routines or programs seemingly simultaneously by overlapping or interleaving their execution; that is, by permitting more than one program to time-share machine components.

Numeric—A machine alphabet that includes only numerals, in contrast to alphanumeric, which has both letters and numerals.

OCR (Optical Character Reader)—An information processing device that accepts prepared forms and converts data from them to computer output media via optical character recognition.

Off-line—Pertains to equipment or devices not in direct communication with the central processing unit of a computer.

On-line—Pertains to equipment or devices directly connected to the central processing unit.

Operating system—A program that controls the overall execution of computer programs. It is available to the computer at all times, either in internal storage or on auxiliary storage.

Operations research—Application of scientific principles to business management. This may involve setting up mathematical equations to depict business problems.

Original equipment manufacturer—A company that purchases computer hardware for use as components in the systems that it sells.

Output—Processed information recorded on a medium such as a business form or magnetic tape.

Peripheral equipment—Any equipment other than the central processing unit of a computer, such as a printer, card reader, terminal, or tape drive that provides outside communication to the system.

PL/1—Higher level programming language with a wide variety of features and applications.

Printer—A device for writing out computer results as numbers, words, or symbols.

Process control computer—A computer that controls a production process, such as steelmaking, petroleum refining, or electric power generation.

Processor—The hardware or software capable of performing or directing the performance of many functions.

Program (noun)—A plan for the solution of a problem. A complete program includes plans for the transcription of data, coding for the computer, and plans for the absorption of the results into the system. The list of coded instructions is called a routine.

Program (verb)—To plan a computation or process from asking a question to delivering the results, including the integration of the operation into an existing system. Thus, programming consists of planning and coding including numerical analysis, systems analysis, specification of printing formats, and any other functions necessary to the integration of a computer in a system.

Punched card—A piece of lightweight cardboard on which information is represented by holes punched in a specific positions.

Real time—The actual time during which a physical process occurs. Pertains to the performance of a computation during the actual time that the related physical process occurs, so that results of the computation can be used in guiding the physical process.

Record—A group of related facts or fields of information treated as a unit. For example, one invoice is a record in a file containing many invoices.

Run—Execute a computer program.

Scanner—That portion of a reading machine having functions of locating materials to be read and converting the optical signal to an electrical signal.

Small business computer—Small, general-purpose computer marketed by mainframers to smaller businesses and first-time users. Prices range from $10,000 to $285,000.

Software—The programs, operating instructions, and other documents that make it possible to use a computer for a specific application.

Source document—An original document from which basic data are taken.

Storage—Pertains to devices capable of retaining data and delivering them on demand at a later time.

Systems analysis—Examination of an activity, procedure, or method to determine what objective is desired, and how operations must be carried out to reach the objective.

Systems programming—Development of programs, such as compilers and operating systems, that control computer operation.

Telecommunications—Transmission of data in the form of signals over long distances via telegraph, radio, or other communications lines.

Terminal—An on-line data entry and display device, usually located away from the central processing unit. If the terminal is 'intelligent', processing devices are built into it and it also can be used for data manipulation.

Throughput—Productivity based on all facets of an operation; e.g., a computer that can read, write, and compute simultaneously would have a high throughput rating.

Time-sharing—Use of one computer by several independent users.

Unbundling—Marketing method in which the computer vendor sells hardware, software, training, and other services separately rather than as a single package.

Universal Product Code—A standard system of marking for labels, adopted by the major supermarkets, food manufacturers, processors, and distributors for use with computerized checkout equipment.

*U.S. GOVERNMENT PRINTING OFFICE: 1981--361-270/4931