Computer Cultural Literacy for Educators

by

David Moursund

Professor Emeritus, College of Education

University of Oregon

This book is available free on the Web at:

Moursund AGATE Foundation

Information Age Education

2020

Table of Contents

Front Matter

Publisher: Information Age Education: Eugene, Oregon, USA.

David Moursund, Author

David Moursund is an Emeritus Professor of Education at the University of Oregon. His professional career includes founding the International Society for Technology in Education (ISTE) in 1979, serving as ISTE's executive officer for 19 years, and establishing ISTE's flagship publication, *Learning and Leading with Technology*, now published by ISTE as *Empowered Learner.*

He was the major professor or co-major professor for 82 doctoral students—six in mathematics and 76 in education. He has presented hundreds of professional talks and workshops throughout the world. He has authored or co-authored more than 60 academic books and hundreds of articles. Many of these books are available free online. See https://moursundagatefoundation.org.

In 2016, with the help of his son Russell Moursund and daughter-in-law Sonia Moursund, Moursund established **Advancement of Globally Appropriate Technology and Education (AGATE)** as a 501(c)(3) corporation designed to contain and expand Information Age Education (IAE). See http://agate.solutions/.

Acknowledgements

Thanks to Ann Lathrop for her editing assistance.

Information Age Education (IAE)

Information Age Education (IAE) is a non-profit company in the state of Oregon founded in 2007 by David Moursund. Its goal is to help improve worldwide informal and formal education at all levels. IAE considers each person to be a lifelong learner and a lifelong teacher. Every interaction a person has with another person is both a learning and a teaching experience. (Just think of an infant child learning to cry when it wants something and how this trains a parent or caregiver!)

The educational systems of our world face the challenge of preparing students for lives in which humans and computer systems will increasingly work together to solve problems and accomplish tasks. The steadily improving capabilities of these computer systems means that our educational systems must be very flexible in order to accommodate both these advances in computer technology and the needs of humans in a rapidly changing world.

IAE is expanding its worldwide reach by beginning to translate selected publications into Spanish. The first translation is *The Fourth R,* now available online as *La Cuarta R.* This book is about roles of computers in Reading, Writing, Arithmetic, and Reasoning (Computational Thinking). Additional Spanish language translations of some IAE publications are available, and volunteers to do additional translations will be appreciated. (Moursund, 2020).

AGATE (Advancement of Globally Appropriate Technology and Education)

Advancement of Globally Appropriate Technology and Education (AGATE) was founded in 2016 by David Moursund, Russell Moursund, and Sonia Moursund. AGATE is a 501(c)(3) corporation whose purpose is to continue and expand the work of Information Age Education (IAE). AGATE has somewhat broader goals than IAE. I like to think of AGATE as working to improve quality of life throughout the world by the use of appropriate education and technology.

Here is a useful analogy that helps to describe the work of AGATE. Think about a village having a "wise" man or woman who serves as a fount of information, knowledge, and wisdom. Now provide this wise person with connectivity to people and information resources throughout the world. Then think about the implications of partially supplanting that wise person with access to artificially intelligent computer systems that are growing steadily more intelligent.

The wise person has human knowledge and skills. The computer system has a different kind of knowledge and skills. Each has strengths and weaknesses. Working together in solving problems and accomplishing tasks, they can surpass either working alone.

Developing and making appropriate use of computer technology is a worldwide challenge. Our educational systems are helping to meet that challenge. The worldwide education-related research that has been done in the past and/or is now underway needs to be appropriately interpreted, disseminated, and used to help improve education across the entire world. AGATE's goal is to expand the current work of IAE to help to accomplish this task. See http://agate.solutions/.

Preface

> "In this work, when it shall be found that much is omitted, let it not be forgotten that much likewise is performed …" (From Samuel Johnson's Preface to *A Dictionary of the English Language*, published in London in 1755. This was the world's first English language dictionary.)
>
> "The achievement of high universal literacy is the key to all other fundamental improvements in American education." (E.D. Hirsch, Jr.; American educator and academic literary critic; 1928-).

This book was inspired by the work of University of Virginia professor E.D. Hirsch. In 1988, he published *Cultural Literacy: What Every American Needs to Know.* In this best-selling book, Hirsch argued that progressivist education had let down America's students by neglecting knowledge in the form of a shared body of information. The book includes a list of **5,000 facts, dates, famous people, works of literature, and concepts** that he believed every American should know. His book and the list have proven to be quite popular. (Core Knowledge Foundation, 2020, link).

Information and Communication Technology (ICT) is now a well-established part of our culture. *Computer Cultural Literacy for Educators* includes a large number of **computer-related facts, dates, people, software (computer programs), hardware (physical machines and devices), and concepts** that have become integral to this culture. Today's teachers and their students need to become familiar with many of these computer-related people and terms. The goal of this short book is to help its readers to expand their own computer cultural literacy.

I view myself, you, and every other person as being both a lifelong teacher and a lifelong learner. Thus, in this book I use the terms *teacher* and *educator* to apply to all people reading the book. Every interaction you have with another person is a teaching and learning event for both of you. My goal in writing this and my other books is to help to improve education at all levels and throughout the world.

The primary intended audience for this book is preservice and inservice educators, and other people interested in improving our precollege educational system. The latter includes parents, School Board members, and all people who help to make decisions affecting the education of our children. I expect that most of my readers will be teachers and/or parents with school-age children. For you, this book will help you to find and introduce yourself to topics that you may decide are important to your students.

The main content of the book is divided into two parts. **Part 1** provides the names of a number of people who have made important contributions to the development of electronic digital computers and their uses, and to the field of computers in education. The astute reader will likely observe that the list is somewhat overloaded with educators.

The focus of **Part 2** is on words and terms that frequently are used in communication about computers and their uses, including hardware, software, publications, and a number of other important computer-related ideas. For many of the terms on the list, there are links to related information, including people known for these ideas.

The **Final Remarks** offers a somewhat philosophical summary of some of my thoughts about improving education. It begins with the observation that *change is non-neutral*. Changes in

technology affect some people more than others. Indeed, many people are disadvantaged by the changes that are occurring. For example, think about people who lose their jobs as a company begins to make more extensive use of robots.

The last section is **Additional References and Resources**. This is a brief supplement to the numerous citations throughout the book that provide access to sources used in my own research and writing.

Part 1

Important People in Computer Cultural Literacy

"It takes a whole village to raise a child." (African proverb.)

"Never doubt that a small group of thoughtful committed citizens can change the world; indeed, it's the only thing that ever has." (Margaret Mead; American cultural anthropologist; 1901–1978.)

Albrecht, Robert (Bob) (1930-). Computer in education pioneer and prolific author who began teaching computer programming to high school students in 1962. He was a 1972 founder of People's Computer Company, a non-profit organization devoted to educational, recreational, personal, and public uses of computers. He was the founder and editor of the *People's Computer Company* journal, 1972-1977. In 1975, was co-founder with Dennis Allison of *Dr. Dobb's Journal*, a professional journal of software tools for advanced computer programmers. In 1977, was co-founder with Don Inman of *Calculators/Computers Magazine*. In 1979, Albrecht terminated this periodical and offered its subscription land advertisers list, as well as some articles awaiting publication, to David Moursund. This helped encourage Moursund to create the International Council for Computers in Education. In approximately 1980, Albrecht was co-founder with Ramon Zamora of ComputerTown, USA, a community computer literacy project funded by the National Science Foundation (ERIC, 1982, link.)

Allen, Paul (1953-2018). Co-founder with Bill Gates of Microsoft, and founder of the Allen Institutes for Brain Science, Artificial Intelligence, and Cell Science; philanthropist. (Wikipedia, 2020, link.)

Babbage, Charles (1791-1871). British inventor who designed the Difference Engine and the Analytic Engine, the world's first digital computers. (Britannica, 2020, link.)

Berners-Lee, Tim (1955-). Invented the Web in 1989, and was one of *Time* magazine's '100 Most Important People of the 20th Century.' He is director of the World Wide Web Consortium, a global web standards organization he founded in 1994. (World Wide Web Foundation, 2020, link.)

Bezos, Jeffrey Preston (1964-). CEO and president of Amazon, a huge multi-national technology company that he founded in 1994. He is an entrepreneur and philanthropist. Amazon owns a number of companies whose products include Kindle e-readers, Fire tablets, Fire TV, and Echo devices. Amazon sells products from its own companies and serves as a retail mail-order distribution outlet for millions of products from other companies. (Wikipedia, 2020, link.)

Braun, Ludwig (1926-2018). A pioneer in the field of computers in education. He received substantial funding through the National Science Foundation to support his work in developing instructional materials and implementing their use in secondary schools. He is perhaps best known for the Huntington Computer Project which developed 17 simulation games used for instructional purposes in high schools. These games were designed to run on digital computers and to deal with material from either biology, physics, or social studies. (Braun, October 1985, link; Moursund, 2016, link; Parabook, 2020, link.)

Brin, Sergey (1973-). Co-founder of Google with Larry Page on September 4, 1998. Google is the world's most widely used Web search engine. Google also provides a number of services and

products such as email (Gmail), cloud storage (Google Drive), language translation (Google Translate), video sharing (YouTube), and maps (Google maps).

> "Google began in January 1996 as a research project by Larry Page and Sergey Brin when they were both PhD students at Stanford University in Stanford, California. The project initially involved an unofficial "third founder", Scott Hassan, the original lead programmer who wrote much of the code for the original Google Search engine, but he left before Google was officially founded as a company; Hassan went on to pursue a career in robotics and founded the company Willow Garage in 2006." (Wikipedia, 2020, link.)

Cerf, Vinton (1943-). "Vinton G. Cerf is vice president and Chief Internet Evangelist for Google. He contributes to global policy development and continued spread of the Internet. Widely known as one of the *Fathers of the Internet*, Cerf is the co-designer of the TCP/IP protocols and the architecture of the Internet." (Google Research, n.d., link.)

Cuban, Larry (1934-). Professor of Education at Stanford University and very prolific writer with a broad range of education experiences. His major research interests focus on the history of curriculum and instruction, educational leadership, school reform, and the uses of technology in classrooms. (Sustainability, n.d., link.)

Engelbart, Douglass (1925-2013). He is known for his work on the invention of the computer mouse, bitmapped graphic display screens, and hypertext. His work in these three areas contributed to Web-users routine experiences when using the Web. (Wikipedia, 2020, link.)

Gates, William (Bill) (1955-). He is a Microsoft Corporation co-founder, with Paul Allen; co-founder with his wife Melinda of the Bill and Melinda Gates Foundation. Entrepreneur and philanthropist. (Biography, 2020, link.)

> Microsoft develops, manufactures, licenses, supports, and sells computer software, consumer electronics, personal computers, and related services. Its best-known software products are the Microsoft Windows line of operating systems, the Microsoft Office suite, and the Internet Explorer and Edge web browsers. (Wikipedia, 2020, link.)
>
> Guided by the belief that every life has equal value, the Bill & Melinda Gates Foundation works to help all people lead healthy, productive lives. In developing countries, it focuses on improving people's health and giving them the chance to lift themselves out of hunger and extreme poverty. (Bill and Melinda Gates Foundation, 2020, link.)

Hollerith, Herman (1860-1929). Considered to be the father of modern automatic computation, he founded the company that was to become IBM. To process the 1890 U.S. census data, he selected the punched card as the basis for storing and processing information, and he built the first punched-card tabulating and sorting machines as well as the first key punch. Hollerith's designs dominated the computing landscape for almost 100 years. (da Cruz, 3/10/2020 link.)

Hopper, Grace Murray (1906-1992). Computer pioneer and programming languages developer who began her programming career in 1944; Navy Rear Admiral, professor, speaker. In 1949, she joined the Eckert-Mauchly Computer Corporation in Philadelphia as senior mathematician. The company was soon acquired by Remington Rand. As head programmer for Remington Rand, she worked on the UNIVAC I (Universal Automatic Computer). In 1952, her programming team developed the first computer language "compiler" called A-0. (*Yale News,*

2/10/2017, link.) Her compiler translates computer instructions that were written in a language understood by human programmers into instructions that can be carried out by a computer.

Jacquard, *Joseph-Marie* *(1752-1834).* French inventor of the Jacquard loom, which served as the impetus for the technological revolution of the textile industry. The punch cards he created to operate his loom machine were later used for many years in data processing, both before and after the development of electronic digital computers. *(Britannica, 2020,* link*.)*

Jobs, Steve (1955–2011). Very innovative computer entrepreneur. He and Steve Wozniak co-founded Apple, Inc., in 1976. Jobs served as Apple's chairman until 1985. He bought Pixar from Lucasfilm in 1986 and served as CEO for its first ten years, then returned to Apple in 1997 as CEO. Some important Apple products include the iPhone, iPad, Apple watch, Macintosh computer, MacBook laptop computer, and Apple TV. (Wikipedia, 2020, link.)

Kay, Alan Curtis (1940-). Known for his 1972 proposed Dynabook (a laptop computer for children), his work on object-oriented programming and the programming language Smalltalk, and his work on graphical user interfaces. (Wikipedia, 2020, link; Moursund; 2018, link.) The first commercially-produced laptop computer was built nine year later, the 1981 Osborne 1. (Bellis, 10/4/2019, link.)

Kemeny, John (1926-1992). "… mathematician, computer scientist, and educator best known for co-developing the BASIC programming language in 1964 with Thomas E. Kurtz. Kemeny served as the 13th President of Dartmouth College from 1970 to 1981, and pioneered the use of computers in college education." (Wikipedia, 2020, link.)

Kilby, Jack St. Clair (1923-2005). While working as a newly hired engineer at Texas Instruments, he invented the first hybrid *integrated circuit* in the summer of 1959. He received a 2000 Nobel Prize in Physics for this work. He is also known for being a co-inventor of the handheld calculator and thermal printer. (Wikipedia; 2020, link.)

Kurzweil, Ray (1948-). Inventor and futurist working in the fields of optical character recognition and text-to-speech (reading for the blind), electronic keyboard instruments, and the futuristic concept named the *Singularity* for a time in the future when computers will have become more intelligent than people. (Wikipedia, 2020, link; Kurzweil Music Systems, n.d., link.)

Kurtz, Thomas (1928-). Director of Dartmouth College Computing Center, 1959-1975. Co-developer, with John Kemeny, of the BASIC programming language. This language and its implementation on the Dartmouth Time Sharing System was the first commercially successful time-sharing system. Instead of batch-processed programs on punch cards, programmers could use teletype keyboard terminals as they wrote, ran, and debugged their programs. (Wikipedia, 2020, link); IEEE Computer Society, 2020, link.)

Lovelace, Ada (1815-1852). British mathematician and writer, known for her pioneering work in the early 1800's (especially her ideas on computer programming) on Charles Babbage's proposed mechanical general-purpose computer the Analytical Engine. (Wikipedia, 2020, link.)

Luehrmann, Arthur (1931-). Author or coauthor of more than 50 educational books about various aspects of computers and programming. He was on the faculty at Dartmouth when time-shared computing using the programming language BASIC was developed by Kemeny and Kurtz. This facility made it possible for Dartmouth to require a course in BASIC for all freshman students, and to integrate use of computers into many of the Dartmouth courses. He was project

director for Project COMPUTe, a three-year effort funded by the National Science Foundation to support "writing and publication of course materials that would support educational use of computing in the undergraduate curriculum," with Thomas Kurtz as the principal investigator. Luehrmann coined the term *Computing Literacy* in 1972, and was one of the founders of the Computer Literacy Press in 1981. (Moursund, 2020, link; Dartmouth: The 1970s, n.d., link.)

M**oore, Gordon** (1929-). Gordon Moore and Robert Noyce co-founded NM Electronics in 1968, which later became Intel Corporation. Moore published an article in 1965 describing that the number of components (transistors, resistors, diodes, and capacitors) in a dense integrated circuit had doubled approximately every year and speculating that it would continue to do so for at least the next ten years. In 1975, he revised the forecast rate to approximately every two years. This came to be known as *Moore's Law,* and it has proved to be relatively accurate for more than 30 years. (Wikipedia, 2020, link.)

Morse, Samuel (1791-1882). Inventor who helped to develop the commercial use of telegraphy. He was a co-developer of the Morse code that uses dots and dashes to code letters, digits, and punctuation. This telegraph code of dots and dashes is akin to the binary bit code of 0 and 1 used by today's computers. (Wikipedia, 2020, link.) Electronic communication over a wire has made a major contribution throughout the world.

Moursund, David (1936-). University of Oregon professor and the author, co-author, and editor or co-editor of about 75 academic books. First Chair of the U. of O. Computer Science Department, 1969-1975. With his College of Education colleague Keith Acheson, he founded the word's first doctoral program for computers in education in 1971. He founded the non-profit professional society International Society for Technology in Education (ISTE) in 1979, and was its CEO for many years. In 2008, he established the non-profit Information Age Education (IAE) organization with a website that offers free books, newsletters, and the *IAE-pedia.* He has served on the Board of Directors of the non-profit Math Learning Center from its inception in 1976. (Moursund, 2020; Wikipedia, 2020, link.)

Musk, Elon (1971-). A very successful engineer, industrial designer, technology entrepreneur, and philanthropist. (Benveniste, 9/1/2020, link.) Some of his current companies include Tesla Motors (electric, autonomous vehicles), SpaceX (spaceships and communication satellites), The Boring Company (tunnels for underground transportation), Neurolink (brain implant to provide connectivity to computers outside of one's brain), and Hyperloop (a transportation system using sealed tubes through which pods carrying people and other contents travel rapidly and energy-wise efficiently due to very low air resistance). He co-founded PayPal. (Wikipedia, 2020, link.)

Noyce, Robert (1927-1990). Co-founder with Gordon Moore of Intel in 1968. A few months after Jack Kilby invented the first *hybrid* integrated circuit in 1959, Noyce independently invented the integrated circuit while working at Fairchild. This integrated circuit (called the microchip) fueled the personal computer revolution. (Wikipedia, 2020, link.)

Page, Larry (1973-). Co-founder of Google with Sergey Brin on September 4, 1998. Google is the world's most used Web search engine. Google provides a number of services and products such as email (Gmail), cloud storage (Google Drive), language translation (Google Translate), video sharing (YouTube), and maps (Google maps).

> Google began in January 1996 as a research project by Larry Page and Sergey Brin when they were both PhD students at Stanford University in Stanford, California. The project

initially involved an unofficial "third founder", Scott Hassan, the original lead programmer who wrote much of the code for the original Google Search engine, but he left before Google was officially founded as a company; Hassan went on to pursue a career in robotics and founded the company Willow Garage in 2006. (Wikipedia, 2020, link.)

Papert, Seymour (1928-2016). MIT professor, mathematician, computer scientist with a strong emphasis on artificial intelligence, and educator. In 1967, Wally Feurzeig, Seymour Papert, and Cynthia Solomon designed the Logo programming language. This language, with its *turtle* that could be programmed to move about a computer screen, has been used by millions of students. (Wikipedia, 2020, link.) Here is a quote from Papert, "Nothing could be more absurd than an experiment in which computers are placed in a classroom where nothing else is changed."

Shannon, Claud (1916-2001). Mathematician, electrical engineer, and cryptographer known as the *father of information theory*. This area of research is a fundamental component of Information and Communication Technology. (Wikipedia, 2020, link.)

Shockley, William (1910-1989). Manager of a research group at Bell Labs that invented the transistor. The group included John Bardeen and Walter Brattain. These three scientists were jointly awarded the 1956 Nobel Prize in Physics for "their researches on semiconductors and their discovery of the transistor effect." (Wikipedia, 2020, link.)

Sokoloff, David. A pioneer in use of microcomputer based laboratory (MBL) as an aid to teaching and learning science at both the precollege and higher education levels. The emphasis of MBL is learning by hands-on doing. (Physics Today, 4/3/2007, link; Sokoloff, April 2020, link.) He received the 2020 AAPT Oersted Medal for his outstanding teaching and research in Physics Education (AAPT, 10/30/2019, link.)

Suppes, Patrick (1922-2014). Stanford University professor who joined the Philosophy Department in 1950. He made significant contributions to philosophy of science, the theory of measurement, the foundations of quantum mechanics, decision theory, psychology, and educational technology. In the 1960s, Suppes and Richard C. Atkinson (future president of the University of California) conducted experiments in using computers to teach math and reading to school children in the Palo Alto area. In 1967, he founded the Computer Curriculum Corporation, which pioneered the computerized learning movement. (Wikipedia, 2020, link.)

Tinker, Robert (1941-2017). Physicist, science educator, and education technology innovator, who pioneered constructivist and probeware (microcomputer-based laboratory) approaches to science education. He served as a co-founder and president of the Concord Consortium from 1994–2009. (Wikipedia, 2020, link; The Concord Consortium, 2017, link.)

Turing, Alan (1912-1954). Mathematician, computer scientist, logician, and cryptanalyst. He is considered to be the father of theoretical computer science and artificial intelligence. He is well known for his work in deciphering the German *Enigma code* used in military communications during World War 2. In 1950, he published an influential paper describing a test (now known as the *Turing Test*) that could be used to help measure progress in the field of Artificial Intelligence. (Wikipedia, 2020, link.)

von Neumann, John (1903-1957). A mathematical genius doing foundational research in game theory and other areas of mathematics. He wrote a seminal paper on the idea that computer programs should be stored in computer memory, so they could be modified by the program that

was being run. This became known as the *von Neumann architecture* and is the basis for virtually all modern computers. (Ranker, 10/3/ 2017, link.) The list of names presented here includes Ray Kurzweil who is noted for many achievements, including his discussion of the technological singularity. However:

> The first use of the concept of a "singularity" in the technological context was John von Neumann. Stanislaw Ulam reports a discussion with von Neumann "centered on the accelerating progress of technology and changes in the mode of human life, which gives the appearance of approaching some essential singularity in the history of the race beyond which human affairs, as we know them, could not continue." Subsequent authors have echoed this viewpoint. (Wikipedia, 2020, link).

Weizenbaum, Joseph (1923-2008). Considered to be one of the fathers of Artificial Intelligence. In 1966, he published a comparatively simple program called ELIZA (named after a character in George Bernard Shaw's play Pygmalion), that performed natural language processing to conduct a psychotherapy-type conversation. His influential 1976 book *Computer Power and Human Reason* displays his ambivalence towards computer technology and lays out his case. (Weizenbaum, 1993, link.)

Wolfram, Stephen (1959-). Known for his work in computer science, mathematics, and theoretical physics. He developed a very widely used Computer Algebra System named Mathematica Wolfram (Screencast & Video Gallery, 2020, link). In 2019, he announced his creation of the Wolfram Language, a computational language (as in *computational thinking*) designed as an aid to representing and solving problems across the disciplines that humans study. (Wolfram, 5/9/2019, link.)

Wozniak, Steve (1950-). Co-founder with Steve Jobs of Apple Inc; electronics engineer, programmer, and philanthropist. "Woz" was the technology leader in developing the Apple 1 in 1975. He was the primary designer of the 1977 Apple II, one of the first highly successful mass-produced microcomputers. (Wikipedia, 2020, link.)

Zuckerberg, Mark (1984-). Facebook co-founder with three of his Harvard University roommates on 2/4/2004. Zuckerberg is the chairman, chief executive officer, and controlling shareholder of Facebook. Legal battles over the ownership of the company continued for years, with two of the initial partners accepting a $65 million settlement in 2008. Over the years, Facebook has purchased more than 70 companies, including Instagram, Atlas, WhatsApp, and Oculus (Ramzeen, 2020, link; Wikipedia, 2020, link.)

Part 2

Important Terms in Computer Cultural Literacy

> "It is change, continuing change, inevitable change, that is the dominant factor in society today. No sensible decision can be made any longer without taking into account not only the world as it is, but the world as it will be." (Isaac Asimov; American writer of science fiction and popular science who wrote or edited more than 500 books; 1920-1992.)
>
> "The medium is the message. This is merely to say that the personal and social consequences of any medium—that is, of any extension of ourselves—result from the new scale that is introduced into our affairs by each extension of ourselves, or **by any new technology**." (Marshall McLuhan; Canadian educator, philosopher, and scholar; 1911–1980.) [Bold added for emphasis.]

Abacus. Arithmetic calculating device invented more than 4,000 years ago. (Wikipedia, 2020, link.) The history of the abacus is a story of people developing devices to aid in doing addition, subtraction, multiplication, and division of integer numbers. Contrast the abacus with paper-and-pencil algorithms for doing such calculations.

Air traffic control system. Highly computerized system to coordinate and control air traffic. (Sheffield School of Aeronautics, 11/27/2019, link.)

Alexa. See **Voice activated response system.**

Algorithm. A finite step-by-step set of instructions designed to solve a particular type of problem or accomplish a particular type of task. (Encyclopedia of Mathematics, 4/3/2020, link.) (Also see **Jeffrey Preston Bezos**.)

Analogue computer. "A type of computer that uses the continuously changeable aspects of physical phenomena such as electrical, mechanical, or hydraulic quantities to model the problem being solved." (Wikipedia, 2020, link.)

Apple, Inc. Multinational technology *company* founded by Steve Jobs and Steve Wozniak in 1976. The company got its start with Apple desktop computers. Its current product line includes the iPhone smart phone, the iPad tablet computer, the Mac personal computer, the iPod portable media player, the Apple Watch smartwatch, the Apple TV digital media player, the AirPods wireless earbuds, and the HomePod smart speaker. (Wikipedia, 2020, link.) (Also see **Steve Jobs, Steve Wozniak**.)

Artificial Intelligence (AI). A branch of computer science concerned with building machines capable of performing tasks that typically require human intelligence. (BuiltIn, n.d., link.) The capabilities of AI have increased rapidly in recent years. (Lauret, 7/22/2020, link.) A 2018 interview with futurist Ray Kurzweil provides an overview of a number of the current AI capabilities, issues, and possible futures. (YouTube, 3/20/2018, link to 61 minute video.)

Today's smart phone has considerable artificial intelligence. It represents a huge step up on the intelligence scale when compared to the first hand held pocket calculator. Researchers and product developers are continuing to make considerable progress on AI-based machines that are further up on that scale. (Also see **Ray Kurzweil, Joseph Weizenbaum.**)

Assembly language programming. The central processing unit (CPU) of an electronic digital computer is designed to be able to execute (carry out, follow) a variety of instructions. Consider an analogy with a four-function hand held calculator. Its processing unit "knows" how to add, subtract, multiply, and divide a pair of numbers. A user depresses one of the four keys +, -, x, or ÷, and the calculator's CPU performs the indicated computation. A typical computer has a quite extensive list of operations it can execute. (Wikipedia, 2020, link.) Each is represented by a binary code. Rather than forcing programmers to memorize and use a long list of binary codes, Assembly Languages were developed to accept words and abbreviations such as ADD, SUB, MUL, DIV, and so on. A programmer writes a program in this so-called low-level language and a computer program translates it into the machine's binary code. It took a number of years before programmers were provided with higher-level programming languages such as BASIC, Fortran, and Cobol in which they could use a combination of words and math symbols in writing programs. This was a huge step forward in increasing the productivity of programmers. (Also see **Programming language.)**

Association for Computing Machinery (ACM). The ACM is a U.S.-based international non-profit professional society founded in 1947, and is the world's largest scientific and educational computing society. More than half of its current 100,000 members live outside the U.S. (Association for Computing Machinery, 2020, link.)

Automatic Teller Machine (ATM). A self-service banking machine for deposits, withdrawals, and other banking activities. (McRobbie, L.R., 1/8/2015, link.) A variety of ideas for such a service were explored in the early 1960s, and the first commercial use began in London, England in 1967. For many years, these "online tellers" did not lead to a decrease in the number of bank teller jobs. Rather, it made it economically profitable for banks to open many small branch offices, and this led to a considerable net increase in the number of in-bank tellers that were needed. (Wikipedia, 2020, link.)

Autonomous vehicle. Mobile devices such as cars, trucks, airplanes, drones, and mobile robots that are controlled by on-board and/or remote computers. (Wired, 2020, link.) There is a huge potential market for autonomous cars, delivery vans, and larger trucks. Tesla is a world leader in this endeavor. (Trefis Team, **7/3/2020,** link.) (Also see **Elon Musk**.)

Backup. A duplicate copy of one's on-computer work, or the process of creating such a copy. (Its Learning, 4/4/2018, link.)

Barcode (bar code). A method for representing data in a visual, machine-readable form that now is exceedingly widely used to identify products being sold in retail stores and for other item identification purposes. Developed by Bernard Silver and Norman Joseph Woodland, their patent was issued on October 7, 1952. (Wikipedia, 2020, link.)

BASIC (Beginners' All-purpose Symbolic Instruction Code). A programming language designed in 1964 by John Kemeny and Tom Kurtz at Dartmouth College to be used on a time-shared computer system. Kemeny and Kurtz wanted to enable students in fields other than science and mathematics to use computers. Fortran was the dominant programming language for use in science and mathematics at that time. Both BASIC and Fortran still are widely used. (Wikipedia, 2020, link.) (Also see **John Kemeny, Thomas Kurtz**.)

Batch processing. Early computers were capable of running only one program at a time. Each user had sole control of the machine for a scheduled period of time. They would arrive at the

computer with program and data, often on punched paper cards, punched paper tape, or a magnetic tape. They would load their program into the computer, run it, and carry off their output when done. (If the program had errors—called bugs—the results might be erroneous or the program might not run at all.) After this program had finished running, the next user's program would be read into the computer and run. Advancements in computer technology made it possible for a sequence of programs (a batch of programs) to automatically be read into the computer at the same time as the computer was running another user's program. This sped up the overall process, as the computer did not have to stop processing one user's program and wait for the next user's program to be read into the computer. This was called *batch processing.* Still later, *time-shared computing* was developed that allowed multiple programs to be running simultaneously on one computer. (Wikipedia, 2020, link.) (Also see **Time-shared computing**.)

Big data. The term big data is used both to describe a very large collection of data and the processes of analyzing very large data sets to solve problems and accomplish tasks. The latter is also called *data analytics,* and is typically accomplished by the use of a combination of human brain power, artificial intelligence, and computers. Using data analytics, large collections of structured, semi-structured, and unstructured data can be mined for its information content and also used in machine learning projects, predictive modeling, and other advanced analytics applications. (Rouse, October, 2019, link.)

Having the ability and facilities to gather and effectively process very large databases is a world changer. The Web and the data collected by the CERN Large Scale Hadron Collider are examples of VERY BIG DATA. (Gaillard, 7/6/2017, link.) By 2017, the CERN database was roughly equivalent in size to 50 full-length novels for every person on earth! (Also see **Data (raw data)**.)

Binary number system (bits and bytes). The *base 10 number system* uses the ten digits 0, 1, … 9. The *binary number system* uses the two binary bits 0 and 1. A group of *eight binary bits* is called a *byte,* and is a commonly used unit of computer storage. One byte can represent any one of 256 different characters such as lower and upper case letters, punctuation marks, and so on. (Rouse, 9/15/2006, link.)

Bitcoin. A digital currency created in January, 2009. Functionally, it is a collection of computers, or nodes, that all run Bitcoin's code and store its blockchain. (Frankenfield, 5/11/2020, link.)

Blog (blogger). A *blog* is a type of publication (typically a continuing sequence of documents) published on the Web. A *blogger* is a person who creates and publishes (posts) such documents. (Wikipedia, 2020, link.) The term blog dates back to the 1990s. Starting in about 2010, groups of individuals and also organizations began to write and publish blog entries.

Blu-ray disc. See **Digital data storage device.**

Broadband connectivity. Connectivity to the Web ranges from very slow to very fast. The U.S. Federal Communications Commission currently defines *broadband* to mean at least 25 million bits per second of download speed, and 3 million bits per second of upload speed. Such specifications vary from country to country. (Wikipedia, 2020, link.) A relatively high speed is needed by students and others participating in online education. The 2020 corona virus pandemic is showing us that many students lack the home connectivity they need.

Browser (Web browser). Computer software designed for browsing (searching) the World Wide Web. Google is a prominent example. (Wikipedia, 2020, link.) (Also see **Search engine**.)

Bug (software bug). An error in a computer program. Use of the word *bug* to designate an error in a constructed device dates back to at least 1878, when Thomas Edison wrote in a letter, "You were partly correct, I did find a 'bug' in my apparatus, but it was not in the telephone proper." On September 9, 1947, Grace Hopper found a moth that had caused a malfunction in an analogue computer. Over the years since then, she often has been credited with finding the first bug in a computer. (McFadden, 6/12/2020 link.) (Also see **Debug computer software**, **Grace Hopper**.)

CD (compact disc). See **Digital data storage device.**

Cell phone. A portable telephone that can send and receive calls over a radio frequency link, also called a *mobile phone.* It lacks a number of the features of a *smart phone.* (Wikipedia, 2020, link.) (Also see **Smart phone**.)

Central Processing Unit (CPU, Processor). A *central processing unit* is a collection of *circuitry* designed to receive and process the binary-coded instructions that constitute a computer program. Often all of this circuitry is contained on a single chip, and it was progress in developing this technology that made possible inexpensive, very powerful microcomputers. Nowadays, even a microcomputer may contain more than one CPU, and supercomputers may contain tens of thousands of CPUs. (Rouse, 9/26/2016, link.)

Chat room. An online communication system in which two or more people can simultaneously communicate with each by text, voice, video or combinations thereof. First used in 1947 in a text-only system developed by David Wooley and Doug Brown. Some chat rooms are designed to facilitate communication for a specific group of people, such as people playing particular computer game. (Techopedia, June 2020, link; Wikipedia, 2020, link.) (Also see **Gaming community chat room**.)

Chat room for gaming. See **Gaming community chat room**.

Chatbot. Computer system that can carry on a conversation (or a chat) with a user in natural language by use of artificial intelligence. (Expert System, 3/17/2020, link.) There are many different chatbots, and there are contests to determine the "best" according to varying intended uses of the chatbot. (Wikipedia, 7/17/2020, link.)

Chip (computer chip, integrated circuit). A collection of tiny electronic circuits on a small, flat piece *(chip*) of silicon or other semiconductor material. (Wikipedia, 2020, link.) (Also see **Integrated circuit (silicon chip)**.

Chromebook. A number of different companies manufacture and sell this *laptop* or *tablet* computer that uses the Linux-based Chrome Operating System. Chromebooks use the Google Chrome browser, with most applications and data residing in the *cloud* rather than on the machine itself. It was first introduced in 2011, and by March 2018, Chromebooks made up 60% of all computers purchased by schools for student use in the United States. (Wikipedia, 2020, link.) (Also see **Laptop computer, Tablet computer.**)

Circuit board (printed circuit board, PCB). Used to mechanically support and to both electrically and electronically connect components in a circuit. Nowadays, these components are generally soldered onto the board by highly automated devices. (Wikipedia, 2020, link.) (Also see **Integrated circuit**.)

Cloud storage. *Cloud* is a widely used term for a data storage system in which data is stored on remote servers (physically located in ground-based computer centers) and accessed using the Internet or other connectivity to users. (Techopedia, 7/18/2017, link.) (Also see **Digital data storage device**.)

Communication satellite. An artificial Earth-orbiting satellite that receives, amplifies, and resends telemetry communications signals via a transponder. The concept of a geostationary communications satellite was first discussed by Arthur C. Clarke in Extraterrestrial Relays, an article published in October 1945, in the British magazine *Wireless World*. (Wikipedia, 2020, link.) In September 2020, when this entry was being written, a company owned by Elon Musk was making rapid progress in orbiting hundreds of communication satellites that, together, will provide Internet connectivity to every location on earth. (Koetsier, 1/9/2020, link.) (Also see **Elon Musk.**)

Computational thinking. Thought processes involved in analyzing a problem and expressing its solution(s) as a procedure that a computer, or a human and computer working together, can carry out. (Moursund, 2018, link.) Knowledge and skill in computational thinking is a major component of computer literacy. (Also see **Computer literacy.**)

Computer (job description). A somewhat archaic term for a *person* who is skilled at a professional level in using aids such as mechanical and electric calculators to rapidly and accurately carry out long sequences of arithmetic calculations. (Wikipedia. 2020, link.)

Computer (machine). "A *machine* that automatically carries out processes, calculations, and other operations specified by instructions in a computer program." (Techopedia, 2020, link.)

Computer-aided learning (CAL). Originally called *computer-assisted instruction (CAI)* when this type of instruction was being developed by Patrick Suppes and others in the 1960s. The term *Computer-aided learning (CAL)* eventually replaced CAI when it became clear that the key goal is *learning*, rather than *instruction.* (Archived Information, 1993, link.)

Substantial research over many years has demonstrated the effectiveness of the use of CAL in a number of different settings. An 8/9/2020 Google search of the expression *research on the effectiveness of computer-assisted learning* produced more than 200 million results. CAL materials vary widely in quality and effectiveness, and students vary widely in how well such materials fit their personal learning characteristics. This is an important ongoing area of research and development, and it is being strongly influenced by progress in artificial intelligence. (Also see **Patrick Suppes**.)

Computer-aided medicine. A broad term covering all aspects of using computers, robots, and artificial intelligence in medical diagnosis, gathering and processing medical data, carrying out medical procedures, dispensing medicines, and so on. (BCS Health and Care, 2020, link.)

Computer Algebra System (CAS). Any computer software with the ability to manipulate mathematical expressions in a way similar to the traditional manual algebraic computations of mathematicians and scientists. The first such systems were developed in the early 1960s. (Wikipedia, 2020, link.) A number of such systems are now in current use. For example, Wolfram Alpha LLC offers both a widely used free version and also commercially available versions. (WolframAlpha, 2020, link.) These make extensive use of artificial intelligence.

Computer game. See **Gaming community chat room, Video game.**

Computer graphics. A branch of computer science dealing with using computers as an aid to generating still and motion graphic images. Two- and three-dimensional computer animation, including virtual reality, have greatly aided and helped to change animation processes. Virtual reality is an emerging power in both entertainment and education. (Wikipedia, 2020, link.)

Computer literacy. Nontechnical and limited-technology knowledge about computers, their applications, and how to use them. The term was widely used as computers were first becoming available to many students in K-12 schools. (Moursund, 1981, link to PDF file.) (Also see **Arthur Luehrmann**.)

Computer mouse (cordless mouse). A pointing device used to interact with a computer. Credited to Douglass Engelbart for his work in the mid-1960s, although key ideas were developed by others about 20 years earlier. (Wikipedia, 2020, link.) The *mouse* with an electric cord coming out of its tail end (hence, why it is called a mouse) is still in use. However, in 1984, a wireless mouse using infrared connectivity to a computer first became commercially available. When the infrared connectivity was replaced by radio frequency, the wireless mouse quickly came into very wide use. (History-Computing, n.d., link.) (Also see **Douglass Engelbart**.)

Computer music. This includes both music produced (that is, performed) by a computerized music synthesizer, as well as original music composed by a computer. (Road, et al., 1996, link.) Ray Kurzweil's research and development laid the groundwork for computer-based musical instruments. (Reid, June 2007, link.) (Also see **MIDI (Musical instrument digital interface)**, **Ray Kurzweil**.)

Computer network. Five types of computer networks, based on their size, are: LAN (Local Area Network); PAN (Personal Area Network); MAN (Metropolitan Area Network); WAN (Wide Area Network); and Internet (a network of networks.) (Javetpoint, n.d., link.) The idea of networking computers goes back to about 1961, but it took until 1971 before the first email message was sent and received. Ten years later, BITNET was created in 1981 as a *network* between IBM mainframe systems in the U.S., and in the same year CSNET (Computer Science Network) was developed by the U.S. National Science Foundation. (Computer Hope, 04/02/2019, link.)

Computer operating system. Computer software that manages computer hardware and software resources, and provides common services used in a variety of computer programs. Widely used examples include Chrome, Linux, macOS, and Windows. (Wikipedia, 2020, link.)

Computer program. A step-by-step *set* of instructions that can be carried out by (executed by) a *computer*, and designed to solve a type of problem or accomplish a type of task. There are many different "higher-level" programming languages used to write computer programs, and new programming languages are being developed from time to time. The first high-level commercially available programming language was Fortran (1956), and it is still widely used. LISP (1958), COBOL (1960) and BASIC (1965) are still in use. The programming languages Logo (1968) and Scratch (2002) were both developed mainly for the use of children and both still are widely used. (Wikipedia, 2020, link.) An extensive list of other programming languages and people involved in developing programming languages is available at the same Wikipedia site. (Also see **Programming language**.)

Computer simulation. The process of developing a mathematical model to be performed on a computer, and that is designed to predict the behavior of and/or the outcome of a real-world or

physical system. For example, weather and climate change forecasters make extensive use of computer simulations. Other examples include car driving and airplane piloting simulators. (Wikipedia, 2020, link.) Courses in modeling and simulation are taught in some high schools, as well as in many post high school institutions. (Modeling & Simulation 101, 8/12/2009, link to 6:17 YouTube video.)

Computer stylus (computer pen). A small pen-shaped instrument with a tip whose location (when positioned on a touch screen) can be detected by the screen. Used both as a pointing device and as a drawing device. (Wikipedia, 2020, link.) (Also see **Graphics tablet, Touch screen**.)

Copy machine. See **Photocopier.**

Core memory (magnetic core memory). The use of *rings* of a hard magnetic material such as iron ferrite, with three or four wires passing through each core, to store one binary bit. The development of core memory was huge step forward in computer technology, and was widely used during 1955-1975. (Wikipedia, 2020, link.)

Data analytics. See **Big Data**.

Data entry. A job in which an employee uses a keyboard and other methods to input data into a computer system. Typically requires the ability to type/keyboard with very few errors at 50 to 80 words per minute. (Computer Hope, 2020, link.) (Also see **Keyboarding/typing**.)

Data (raw data). A collection of facts and/or figures. Data that has been processed, organized, structured, or presented in other manners to make it more useful is called *information.* (Thakur, n.d., link.) One way to think about this is that data is processed into information, information is processed into knowledge, and knowledge is processed into wisdom. (Moursund, January 2006, link.) Wisdom includes having foresight of possible outcomes of the decisions and actions one might take. (Also see **Big data.**)

Data processing. Data in its "raw" form is converted into more useful/organized formats as an aid to solving problems and accomplishing tasks. In many cases, this begins with getting the data into a computer-readable form. Once data is stored in a computer, it can be manipulated (processed) using a wide variety of both general purpose and special purpose software. For example, a variety of readily available programs that can be used to convert data into graphs, charts, spreadsheets, and databases are in common use. Many businesses make use of specialized programs written to fit their specific business needs. (Pearlman, 5/27/2020, link.)

Data storage device. See **Digital data storage device, Disk drive.**

Database. A collection of data—which may or may not be on a computer—organized so that it can easily be accessed, managed, and updated. The Web provides an excellent and humongous example. (Guru99, 2020, link.) In 2020, the Web contains about 4.2 billion Web pages that can be accessed by the widely used browsers. (Wikipedia, 2020, link.) (Also see **Deep Web**.)

Debug computer software. Locate and correct errors in a computer program. (Techopedia, 2/2/2017, link.) Debugging is an important component of computer programming. (Also see **Bug**.)

Deep Web. The parts of the Web whose contents are not indexed by standard Web *search engines (browsers).* It is estimated to be more than 300 times as large as the part of the Web accessed by Google and other commonly used Web browsers. (Wikipedia, 2020, link.)

DIALOG. An online information storage and retrieval system developed by Lockheed Martin in 1966, and owned today by Pro-Quest. It was widely used long before the development of the Web. In the 1980s, a low-priced dial-up version of a subset of DIALOG named *Knowledge Index* became available. Remnants of the original DIALOG system are still in use. (Wikipedia, 2020, link.)

Digital camera. A still or motion image capturing device that stores the captured images digitally. Such images can then be viewed immediately, and can be edited using computer technology. Digital cameras were developed in the mid 1970s. (Wikipedia, 2020, link.)

Digital data storage device. Used for the temporary or permanent storage of digital data. Punch cards were the first such storage medium. Other widely used storage devices include magnetic tape, hard drive disk, floppy disk, CD (compact disc), DVD (digital video disc), Blu-ray disc, flash drive, secure digital card (SD card), and solid state drive (SSD). (Goodman, 7/12/2020, link.) (Also see **Disk drive, Magnetic tape, Thumb drive (flash drive)**.)

Digital filing cabinet (for teachers). An electronic digital dataset specifically designed to meet the digital storage and retrieval needs of preservice and inservice teachers. (Moursund, 2016, link.) (Also see **David Moursund**.)

Digitizer. See **Graphics tablet.**

Disk drive (hard drive, magnetic disk drive). A magnetic disk is a flat, circular platter coated with magnetizable material and used as a computer digital data storage device. A disk drive holds, spins, reads, and writes magnetic disks. First made available by IBM in 1956. (Wikipedia, 2020, link.) (Also see **Digital data storage device.**)

DVD (digital video disc). See **Digital data storage device.**

E-book (electronic book). An e-book is a book or other print materials in electronic digital format designed to be read on a computer or on a device designed specifically for reading electronic books. While a specific invention date has not been agreed on, some historians consider electronic books to have started in the early 1960s, with (1) the NLS project headed by Douglas Engelbart at Stanford Research Institute (SRI), and (2) the Hypertext Editing System and File Retrieval and Editing System (FRESS) projects headed by Andries van Dam at Brown University. (Wikipedia, 2020, link.) It is estimated that Amazon, Inc. carries more than 6 million e-books. (Haines, 7/15/2020, link.) A number of sites now offer free e-books. (Bowsher, 5/72020, link.)

email (electronic mail). A method using electronic devices to exchange messages (*mail*) between people. In 1971, Ray Tomlinson developed the first email system able to send mail between users on different computer systems across the ARPANET (an early computer network) using the @ sign to link the user name with a destination server. (Wikipedia, 2020, link.) *Texting/messaging* displays the communication immediately on the recipient's receiving device, such as a smart phone. (Khillar, 6/14/2018, link.) *Email* adds the communication to the receiving device's list of email messages received, but requires opening the received document in order to read it. (Also see **Texting/messaging**.)

Emoji. Small pictures such as smiley faces, hearts, flags, symbols, and so on, that are used on smart phones, tablet computers, and other electronic devices to convey emotions. (Emojipedia, 2020, link.)

ENIAC (Electronic Numerical Integrator and Computer). The first general-purpose programmable electronic digital computer. This computer was designed by John William Mauchly and J. Presper Eckert while working at the University of Pennsylvania's Moore School of Electrical Engineering. Funding for the project was provided by the U.S. Army. ENIAC began productive use in the U.S. on December 10, 1945. (Wikipedia, 2020, link.)

eSports. Organized, multiplayer video amateur and professional game competitions between individuals and teams. eSports are an increasing component of interschool competition at the precollege and higher education levels. Since the 2010s, eSports have been a significant factor in the video game industry, with many game development companies actively providing funding for tournaments and other events. (Dell Technologies, 2020, link; Wikipedia, 2020, link.)

Exascale computer. Exascale is computing starting at 10 to the 18th operations per second—or a billion-billion operations per second. This is about a thousand times as fast as the current (2020) super computers. Expectations are that the first such computer will become operational in 2021 at the Argonne National Laboratory that is located near Chicago, Illinois. (Dan Tynan, 10/7/ 2020, link.) (Also see **Supercomputer**.)

Expert system. A computer program that makes use of artificial intelligence to aid in solving a type of problem or accomplish a type of task. A 6-function electronic calculator satisfies that definition, as does a computer program that plays games such as Chess and Go at a very high level. Web browsers and language translation systems provide examples of expert systems that are in routine, widespread, use. (Wikipedia, 2020, link.)

Facebook. Free social networking site that makes it easy for people to connect and share information online, and is the world's most widely used social networking site. (Wikipedia, 2020, link.) Facebook had more than 2.6 billion users (30 percent of the world's total population) in the first quarter of 2020. (statista, 2020, link.) (Also see **Instagram, Social networking, Mark Zuckerberg**.)

Facial recognition. A computer-based process of identifying a person from a picture. This picture may come from a video camera, such as might be used to view customers in a store, or from a picture taken using a smart phone. (Thales, n.d. link.)

Fact checker. A person or computer system that checks the accuracy of *purported* facts and statements. Fact checkers are used to help combat the deluge of *fake news* being broadcast, posted on the Web, and distributed by other means. A number of lists of fact checking websites are available. (Wikipedia, 2020, link.) (Also see **Fake news**.)

Fake news. "False news stories, often of a sensational nature, created to be widely shared or distributed for the purpose of generating revenue, or promoting or discrediting a public figure, political movement, company, etc." (Dictionary.com, n.d., link.)

Fiber optics. The use of thin flexible fibers made of glass or other transparent solids that are about the thickness of a human hair, and are used to transmit light signals. (See 7:30 video on YouTube, 2/12/2019, link.)

Floppy disk. An inexpensive type of secondary storage for computers consisting of a flexible (bendable plastic) disk coated with magnetizable material. Widely used with microcomputers in the late 1970's and throughout the 1980s. (See 2:33 video on YouTube, 8/30/2011, link.) Floppy disks largely replaced cassette magnetic tapes that earlier had been used for secondary storage on microcomputers. In the early 2000's, floppy disks were largely replaced by compact disks (CDs)

that use lasers for reading and writing data. The Web (for example "cloud" storage), thumb drives, and hard drives have largely replaced read/write CDs. (Also see **Digital data storage device.)**

Fortran (Formula Translation.) In late 1953, John W. Backus submitted a proposal to his superiors at IBM to put together a team of ten programmers to work on developing an alternative to *assembly language programming* that would be easier to use. The Fortran project was approved, and was completed in April, 1957. Fortran became very popular and is still widely used throughout the fields of engineering, mathematics, and science. (Wikipedia, 2020, link.)

Gaming community chat room. The popularity of online computer games has led to the development of a number of chat rooms designed specifically for game players. (Slant, 2020, link.) *Discord* is a popular example of such a site. (Hornshaw, 5/8/2020, link.) It and other game player sites are designed to deal with the problems of helping game players communicate with each other and to socially interact in groups while playing games. (Also see **Chat room**.)

Go viral on the Internet. A piece of news, an image, or a video that becomes exceedingly widely distributed by being shared by a very large number of computer users within a matter of hours or just a few days after first being posted. (Thales, n.d., link.)

Google. For most people, the term *Google* has two distinct meanings. First, there is a *company* named Google, Inc. started by Larry Page and Sergey Brin, and officially launched in 1998. (Wikipedia, 2020, link.) This company is now a subsidiary of the holding company *Alphabet Inc.*, an American multinational conglomerate headquartered in Mountain View, California. It was created through a restructuring of Google on October 2, 2015. Second, there is a *search engine* (a Web browser) now named *Google Chrome* (but usually referred to as the *Google search engine*, or just *Google*) that is by far the most widely used search engine in the world. (Reliablesoftware.net, 2020, link; Wikipedia, 2020, link.)

This search engine can process search requests in more than 70 different languages, and can automatically use *Google Translate* to translate retrieved documents into more than a hundred different languages. (Nguyen, 12/9/2019, link.) (Also see **Search engine**, **Sergey Brin, Larry Page**.)

Google Translate. This free computer-based language translation system handles more than 100 written languages and more than 60 voice input (spoken) languages. **(**Google Translate, 2020, link.) (Also see **Language translation by computer**.)

GPS (Global Positioning System). A U.S.-owned and operated utility that provides users with positioning, navigation, and timing services. Work on this project began in the early 1970s, with a prototype available in 1978. Use was originally limited to the U.S. military, but the system was opened to civilian use early in the 1980s. The system makes use of 24 orbiting satellites. (GPS.gov, 3/18/2020, link.)

Grammar checker/spellchecker. Software used with a word processor to check the correctness of both the spelling and the grammar in a written document. As more and more people do their writing using a word processor, this has led schools to reconsider both the importance of having students learn cursive writing, as well as requiring that they develop a high level of skills in spelling and grammar. (Grammarly, n.d., link.) (Also see **Spellchecker/grammar checker.**)

Graphics tablet (digitizer). A computer input device that uses a special pen-like stylus to hand-draw images for input to a computer and display on a computer screen. It is used to create

animations and graphics, and also to capture handwritten data and signatures. (Wikipedia, 2020, link.) Some computer screens, such as those used for smart phones and many tablet computers, are both digital display screens and digitizers. (Also see **Computer stylus**.)

Grid energy storage (**large-scale energy storage.)** Methods of storing energy (such is in rechargeable batteries) or resources for the rapid production of energy (such as water behind a dam that can power electrical generators). The objective is to have rapid and relatively inexpensive means of producing electricity when solar and wind resources are not available, or to meet unexpected surges in demand. (Wikipedia, 2020, link.)

Hacking. Malicious activities that seek to compromise (disrupt, steal from) digital devices, such as computers, smart phones, and entire computer networks. (Malwarebytes, 2020, link.) (Also see **Malware, Phishing**.)

Handheld electronic calculator (pocket calculator). In 1972, Hewlett-Packard produced the first Scientific Calculator, and HP produced the first handheld programmable calculator in 1974. Graphing calculators became available on the mid 1980s. The most powerful of current handheld programmable calculators have capabilities somewhat like a modest-priced full scale laptop computer, but with limited screen and keyboard size. (Wikipedia, 2020, link.)

Hard drive. See **Digital data storage device, Disk drive.**

Hashtag. A number of social networking systems allow one to insert a *hashtag* (a string of characters beginning with the # symbol) either at the end of a message or within a message. For example, *#blacklivesmatter* has become an important and widely used hashtag. Anyone who is signed into the social networking system can search for and retrieve all messages in the system that contain a specified hashtag. (Wikipedia, 2020, link; Twitter, n.d., link.) (Also see **Social networking**.)

Hollerith card. See **Punch card.**

Holodeck. A holographic environment simulator that was an ongoing part of the Star Trek science fiction TV and movie series. (Fandom, n.d., link.) A forerunner of the use of Artificial ` Intelligence to simulate life-like people functioning in their environments. The Holodeck was first used in 1974 in an animated Star Trek video. (The Conversation, n.d., link.)

Hotspot. "A physical location where people can access the Internet, typically using Wi-Fi, via a wireless local area network (WLAN) with a router connected to an Internet service provider." (Intel, n.d., link.)

Inalienable rights (unalienable rights). The *U.S. Declaration of Independence* specifies that "*Life, Liberty and the pursuit of Happiness*" have been given to all humans by their creator, and are something which governments are created to protect. The 1948 United Nation's *Universal Declaration of Human Rights* includes civil and political rights, including the right to life, liberty, free speech, and privacy. It also includes economic, social, and cultural rights, like the right to social security, health, and education. (United Nations, n.d., link.) A 2004 update stresses education. (United Nations, 1/20/2004, link.)

The ideas about inalienable rights in these documents are independent of any particular technology or technological advances, but certainly are impacted by such advances in technology. My personal opinion is that this entry is the most important of all of the entries in these lists.

At the current time, various countries and the world as a whole are considering issues such as smart phone and broadband availability for all people. The Corona virus pandemic has led more people to think about nationwide and global availability of high quality computer-assisted learning materials for use both at home and in schools. This would be an extension of the widely accepted idea that all people should have access to books in their homes.

Instagram. A photo-sharing social network site owned by Facebook. Users can upload, edit, and tag photos and videos. As of July 2020, Instagram had more than a billion users per month. (Statista, 6/24/2020, link.) (Also see **Facebook, Social media, Social networking**.)

Instant messaging. An online, real-time text messaging system. The effect is somewhat like a telephone conversation of very short messages, but uses a keyboard to create the short messages. (Wikipedia, 2020, link.) (Also see **Email, Texting/messaging**.)

Institute of Electrical and Electronics Engineers (IEEE). The IEEE was founded in 1963 by the merger of the American Institute of Electrical Engineers and the Institute of Radio Engineers. It is the world's largest technical professional organization. (IEEE, 2020, link.) It has about 420 thousand members located in 160 countries throughout the world. (IEEE at a glance, 2020, link.)

Integrated circuit (silicon chip). A large set of electronic circuits on one small flat piece (or *chip*) of semiconductor material that normally is made of silicon. (Infoplease, 2012, link.) (Also see **Chip (computer chip, integrated circuit), Circuit board.)**

International Society for Technology in Education (ISTE). A non-profit professional society founded by David Moursund in 1979. "ISTE inspires educators worldwide to use technology to innovate teaching and learning, accelerate good practice, and solve tough problems in education by providing community, knowledge, and the ISTE Standards, a framework for rethinking education and empowering learners." (ISTE, 2020, link.) ISTE has members in more than 100 countries. (Wikipedia, 2020, link.) The 2019 ISTE conference in Philadelphia, Pennsylvania had about 15,000 attendees from 72 countries. (Also see **David Moursund**.)

Internet. A globally connected computer network system to transmit data. People often confuse the Internet and the Web. This distinction may be clarified by thinking of the *Internet as the connectivity*, and the *Web as a steadily growing collection of content* that is being accessed on the Internet. (Techopedia, 8/30/2019, link.) The Internet has a long history, with many people contributing to its development. (Router Admin, 2020, link.) In the early 1960s, MIT's J.C.R. Licklider popularized the idea of an "Intergalactic Network" of computers. (Andrews, 10/28/2019, link.) (Also see **Web**.)

Jacquard loom. Invented in 1804 by Joseph-Marie Jacquard, this loom made it possible for complex and detailed patterned fabrics to be rapidly manufactured by unskilled workers. (Science & History Museum, 6/25/2019, link.) In some sense, the Jacquard loom had a type of artificial intelligence (a capability) that allowed the machine to replace a skilled worker. (Also see **Joseph-Marie Jacquard**.)

Keyboarding/typing. A number of different instruments, such as a piano, typewriter, and computer have keyboards. Historically, people learning to make fast and accurate use of a typewriter took courses in *touch typing.* Now, such a course may have either the word *typing* or *keyboarding* in its title, although typewriters have largely disappeared. (Wikipedia 2020, link.) A number of free and commercial keyboarding courses are available on the Web. An 8/29/2020

Google search using the expression *free keyboarding OR typing lessons* produced more than 40 million results. (Also see **Data entry.**)

Language translation by computer. Text or voice messages in one language can be translated by a computer into text or voice in a different language. In 2020, *Google Translate* offered free translation services for 109 different languages entered by keyboard, and 64 different languages entered by voice. (Wikipedia, 2020, link; Google Translate, 2020, link.) (Also see **Google**, **Google Translate.**)

Laptop computer. A portable computer, usually both battery-powered and AC-powered, small enough to rest on the user's lap, and having a screen that closes over the keyboard—rather like a clam shell. "The computer considered by most historians to be the first truly portable computer was the Osborne 1. Thai born book and software publisher Adam Osborne (1939–2003) was the founder of Osborne Computer Corp, which produced the Osborne 1 in 1981. It was a portable computer that weighed 24 pounds and cost $1,795. For that, users got a five-inch screen, modem port, two 5 1/4 floppy drives, a large collection of bundled software programs, and a battery pack." (Bellis, 10/4/2019, link.) (Also see **Microcomputer, Personal computer, Tablet computer, Alan Kay.**)

LinkedIn. A social network owned by Microsoft that is designed specifically for career and business professionals. At no cost, a person can create a personal (professional) profile of information that is to be shared with others users of the system. In 2019, LinkedIn had more than 700 million users throughout the world. (LinkedIn, 2020, link.) Users with a paid subscription are able to gain access to additional information that may help them in their careers and businesses. (Duermyer, 11/11/2019, link.) (Also see **Social networking**.)

Logo. An educational programming language designed in 1967 by Wally Feurzeig, Seymour Papert, and Cynthia Solomon. A computer-controlled graphic called a *Turtle* was added to the language in 1969. A computer program could move the Turtle about the display screen. Average students can learn and enjoy programming in Logo at about age 7. Logo has been taught in many schools throughout the world. (Wikipedia, 2020, link.) (Also see **Scratch, Seymour Papert**.)

Machine learning. For each term listed so far in this document, I have provided a relatively brief definition and/or explanation. The term *machine learning* does not lend itself to such briefness. Machine learning is a major change agent in our world, and surely is one of the most important topics in our list of terms. This situation has led me to writing a short essay rather than a brief response for this entry. It is by far the longest entry in the *Important Terms* part of this book.

Many problems and tasks that humans would like for computers to be able to handle well are far beyond our human ability to do the necessary *figuring out how to solve the problem* and then *writing the needed computer programs.* **Machine learning is a process of using a computer to examine a very large number of examples, and then independently figure out a solution. The computer then writes its own program on how to solve the problem or accomplish the task. In essence, the computer learns how to program itself to meet the stated goal.** (Iriondo, 10/15/2018, link; MathWorks, 2020, link.) Recent progress in this approach to using AI has been very fruitful.

Here is a simple example to introduce some of these AI ideas. Suppose we want a computer to look at a picture that is either a cat or a dog, and then be able to very accurately determine

whether it is a dog or a cat. With a modest amount of experience, children can become quite good at this task. But, this has been a major challenge to humans trying to write AI programs to accomplish this task. Today, we can show a machine learning program many thousands of pictures of dogs and cats, each time telling the machine which is a dog and which is a cat. The machine eventually learns from this huge number of examples to be quite accurate in distinguishing dogs from cats. (Wikipedia, 2020, link.)

The dogs and cats challenge is modest when compared with developing a computer program to defeat a human world champions at a complex board game such as Go. That is because the computer is faced by a well-qualified human opponent and the number of possible different games is overwhelmingly large. (In identifying dogs and cats, there is no opponent.)

A somewhat similar approach of making use of a large number of examples is used in having a computer learn to play a complex game such as Chess or Go. Since it is easy to determine the winner from the loser in these games, this problem lends itself to the computer analyzing many games played against each other by human experts. Using such an approach, a computer program learned enough defeat the world Go champion in 2016. (Wikipedia, 2020, link.) This was considered to be a major achievement in 2016.

Next, AI researchers working on this problem decided to have the computer learn by just playing games against itself, rather than by analyzing games played by human experts. In 2017, a computer system learned by playing 4.9 million Go games against itself over a period of three days. The new program of Go then was able to readily defeat the previous computer-generated Go programs. Indeed, the best of the earlier Go programs played a 100-game match with the newest version of Go-plying program, and the new program won all 100 matches. (Kennedy, 10/18/17, link.)

Finally, let's move beyond games to a *real world* task of developing safe autonomous cars. This is far more challenging than programming a computer to play Go. The current approach is essentially using a combination of the two approaches described above. It uses data being gathered from existing self-driving cars as they are driving, and data generated by computer simulations of self-driving cars in simulate driving environments. Success is measured by producing a self-driving vehicle with a safe-driving record that is far better that of average human drivers. However, there is no expectation that the autonomous car will never have an accident.

Here is a question to think about. Which is harder: Being very highly qualified at teaching a child to read (or do math, etc.) or teaching a car to drive itself? My personal (year 2020) opinion is that because of the human elements involved, teaching reading is the more complex challenge.

However, I expect that in terms of the pure mechanics of teaching a child to read, computer aided learning (CAL), or other curriculum that is not focusing just on human-to-human communication with its sharing of feelings and emotions, will prevail. Such programs will have voice input and output capabilities, use multimedia, and be highly interactive. In addition, highly individualized CAL will draw heavily on information about each student. I marvel at the amount of research and development that has been occurring in recent years to develop fully automated cars, and I wonder what CAL would be able to accomplish if similar resources were put into research and development of AI-based CAL.

The math education topic is more complex. This is because we already have artificially intelligent computer programs that can solve the full range of math problems that students study up through high school and on into their first year or so of college math. We can draw a parallel with arguments about the use of calculators in math education. We have not yet been able to adequately resolve the issue of allowing students to use simple 6-function calculators, scientific calculators, graphing scientific calculators, and artificially intelligent programmable graphing calculators on math tests. Much of these issues boil down to what it means *to know and be able to use/do math.* The mechanics of math are a modest part of what we want students to be learning.

Also note that in teaching reading, we do not lock-step students nearly as much as we do in teaching mathematics. You might want to ponder why this is the case. Likely artificial intelligence-based math CAL will have the capabilities to be successful in addressing lock-step math instruction issues.

Magnetic ink. Very small iron particles are added to the ink that will be used to print the document in order to make it possible for the printed information to be read electronically. For example, the check number, sort number, and account number of bank checks are printed using magnetic ink so the information can be read and the checks processed by very fast, automated sorting machines. (Beal, 2020, link).

Magnetic tape. A long, thin strip of plastic film coated with magnetizable material. Invented in Germany in 1928, it revolutionized industries that made use of the recording, editing, and playback of sound. As computers became commercially available, magnetic tape was used extensively for secondary storage, and still is widely used for this purpose because of its low cost. (Wikipedia, 2020, link.) (Also see **Digital data storage device.**)

Mainframe computer. Very fast, large-scale computers, as distinguished from microcomputers, laptop computers, tablet computers, and also from the ultrafast machines called supercomputers and quantum computers. (Wikipedia, 2020, link.) (Also see **Quantum computer, Supercomputer**, **Exascale computer**.)

Maker machine. See **3D printer**.

Malware (*malicious software).* A catchall term for viruses, worms, trojans, and other harmful computer programs used deliberately by malicious people to wreak destruction on another person or website, to gain access to sensitive information, to hold a user's data for ransom, and so forth. (Fruhlinger, 5/17/2019, link.) (Also see **Hacking, Phishing, Ransomware**.)

Messaging. See **Texting/messaging.**

Microcomputer (personal computer). The original term, now considered to be outdated, for a computer that uses a *microprocessor* for its central processing unit. The 4-bit and 8-microprocessors developed in 1971 and1972 by Intel lacked the speed and processing power needed by a general purpose microcomputer. By the mid 1970s, continued progress by Intel and other companies led to the development of the central processing unit (CPU) chips and microprocessors used in the early commercially available microcomputers such as Apple, Atari, Commodore PET, IBM PC, and TRS-80. (PCmuseum, 3/5/2002, link.) (Also see **Personal computer**.)

Microcomputer-based Laboratory. A science education laboratory commonly available at both the precollege and higher education levels in which microcomputers and data sensors collect,

store, process, and analyze data. The sensors are commonly referred to as probeware. Robert Tinker is known for his pioneering work in developing probeware uses in education. (Wikipedia, 2020, link; Laws, Willis, & Sokoloff, September 2015, link to PDF file; Sokoloff, Laws, & Thornton, 2007, link to PDF file.) (Also see **Robert Tinker**.)

Microprocessor. A one-chip Central Processing Unit. (Also see **Microcomputer, Personal computer.**)

Microsoft. A multinational computer technology corporation headquartered in Seattle, Washington. It was founded on April 4, 1975, by Bill Gates and Paul Allen. Its current best-selling products are the Microsoft Windows operating system; Microsoft Office, a suite of productivity software; Xbox, a line of entertainment of games, music, and video; Bing, a line of search engines; and Microsoft Azure, a cloud services platform. (Wikipedia, 2020, link; YouTube3/27/2019, link; 16:25 Video.) (Also see **Paul Allen, William (Bill) Gates**.)

MIDI (Musical Instrument Digital Interface). A widely accepted set of specifications developed in 1983 to be built into electronic musical instruments such as an electronic piano or guitar. The first major update of the *MIDI specification* since 1983 was released in January, 2019. (DuBreuil, 2020, link.) (Also see **Computer music**.)

Minnesota Educational Computing Consortium (MECC). Professional organization founded in 1973, with a goal to develop, coordinate, and provide instructional computing services to K-12 schools in Minnesota. This state was an early adopter of computer use in the schools when, in 1963, a group of teachers at the University of Minnesota College of Education's laboratory school introduced computers into classrooms via teleprinters and time-sharing. With the founding of MECC, Minnesota became a leading role model for computers in education. MECC also developed many of the outstanding K-12 instructional programs marketed for use by the early microcomputers. The Oregon Trail is an example of MECC software still used in schools today. (Wikipedia, 2020, link; Oregon Trail, Fifth Edition, 2020, link). (Also see **Computer-aided learning.**)

Moore's Law. In an article published April 19, 1965, Gordon Moore (later, a co-founder of Intel Corporation) observed that the number of components (transistors, resistors, diodes, and capacitors) in a dense integrated circuit had doubled approximately every year and speculated that it would continue to do so for at least the next ten years. In 1975, he revised the forecast rate to approximately every two years. This came to be known as *Moore's Law.* (Wikipedia, 2020, link.) An 8/23/2020 article reported about recent research progress at Intel which suggests that Moore's Law may continue to hold for another 10 years. (Dorrier, 8/23/2020, link.) (Also see **Gordon Moore**.)

Mouse. See **Computer mouse (cordless mouse).**

Multimedia. Content that uses a combination of different forms of media such as text, audio, images, animations, video, and interactive content. (Lexicon, 2020, link.) All or most of these are combined in many Web documents and in computer-aided learning materials.

Netflix. A very large American technology and media services provider and production company. During 2013 to 2020, Netflix itself produced more than 1,500 videos. It serves customers in more than 190 countries, both with self-produced videos and many thousands of videos produced by other media companies. Netflix was founded in 1997 by Reed Hastings and Marc Randolph in Scotts Valley, California. As of April 2020, Netflix had more than 193 million

paid subscriptions worldwide. About 73 million were in the United States, and about 120 million were from outside the United States. (Wikipedia, 2020, link.) (Also see **Social media, YouTube**.)

Neural implant. Electrical circuitry implanted in a brain and other locations used to stimulate parts and structures of the nervous system. Implants also are used to record electrical activity of nerve cells. Neural implants currently are being used to treat disease, rehabilitate the body after injury, improve memory, communicate with prosthetic limbs, and more. In 1997, the U.S. Food and Drug Administration approved Direct Brain Stimulation as a treatment for Parkinson's disease. Quoting from a 2020 research article by Emily Waltz published in the *IEEE Spectrum*: "It sounds like science fiction, but a neural implant could, many years from now, read and edit a person's thoughts." (Waltz, 1/20/2020, link.) (Also see **Wearable computer**.)

Online. Being connected via the Internet or other computer networks to people, databases (such as the Web), computer-controlled machines, computer-aided learning materials, stores (for online purchasing), and so on. The current pandemic has led to a major increase in online use because of the many persons now working from home as well as the great numbers of K-12 and college students now receiving online instruction. (Usciences, n.d., link; Wikipedia, 2020, link.) (Also see **Remote work**.)

Personal computer (microcomputer). A computer such as a laptop or tablet designed to be used, and often owned, by a person who is not a computer or technical expert. (Of course, most experts in the computer field own and use a personal computer.) The term *microcomputer*, used to designate a computer whose Central Processing Unit is a microprocessor, is now considered out of date. A CPU may contain a number of microprocessor chips, each carrying out calculations. (Wikipedia, 2020, link; Lithmee, 8/1/2018, link.) (Also see **Laptop computer**, **Microcomputer**, **Tablet computer**.)

Personal data. Also known as personal information or personally identifiable information, it is any information relating to an identifiable person. Collecting, using, and selling personal data is a major, serious problem throughout the world. Definitions and regulations about the collection and use of personal data vary among countries. The regulations in Europe are stricter than those in the United States.

The General Data Protection Regulation (GDPR) is the European Union's new legal framework which governs the collection and processing of users' personal data. The GDPR will take effect on May 25, 2018. The GDPR applies to all entities based in an EU country that process personal data, as well as all entities worldwide that process personal data belonging to EU residents. (At Internet, 2020, link.)

Phishing. "The fraudulent attempt to obtain sensitive information, or data, such as usernames, passwords, and credit card details, by disguising oneself as a trustworthy entity in an electronic communication." (Wikipedia, 2020, link.) (Also see **Hacking**, **Malware**.)

Photocopier (copier, copy machine). A machine that quickly makes copies of documents and other visual images onto paper or plastic film. Although developed by Chester Carlson in the 1940s, it wasn't until 1959, that Xerox released the "914"—the first easy-to-use *photocopier*. (Thompson, March 2015, link; Woodford, 11/2/2019, link.)

Pinterest. An American image sharing and social media network designed so users can *pin* (save and share) ideas and images. In 2017, Pinterest introduced an artificial intelligence-based search

function that allows users to search for elements in images (existing pins, existing parts of a photo, or new photos). As of August 2020, Pinterest had 400 million monthly users. (Wikipedia, 2020, link.) (Also see **Social media**.)

Plagiarism. Plagiarism is in this list mainly because computers and the Web are a great aid to those who want to plagiarize, and also because they are a great aid to those who want to detect plagiarism.

First, a definition. Consider the situation in which a person produces a communication expressing personally-created thoughts and ideas. Under copyright law in most of the world, a work is given copyright protection the moment it is created. This means that others cannot copy the work, distribute it, publicly display/perform the work, or create derivative works of it without the permission of the creator or rights holder. (Turnitin, LLC, 2017, link.) It is considered to be plagiarism if another person who has received the communication makes use of its content and/or ideas and passes them off as his or her own without giving appropriate credit to the original creator.

This plagiarism can be blatant, such as copying an article from a publication, making changes to the wording, and presenting it as one's own work. It also can be a quite innocent mistake, and/or be due to not knowing when such acknowledgement is necessary.

Plagiarism detection (**content similarity detection).** Locating instances of plagiarism and/or copyright infringement within a work or document. A substantial industry has developed to provide software that can detect possible plagiarism. Many websites sell this service or provide it free. (Wikipedia, 2020, link.) A 7/31/2020 Google search of the term *free plagiarism checker* produced more than five million results. Turnitin is a commercially available site used by more than 15,000 institutions throughout the world. (Turnitin, 2020, link.)

Predictive text. A computer technology used while composing text messages and by some word processors that anticipates and then suggests possibly appropriate words to a user based on the letters being entered and the overall context of the phrase being written. (techopedia, 7/1/2020 July 1, 2020, link.) A word processor that suggests corrections to a word that has been entered is using a type of predictive text technology. (Also see **Word processor.**)

Programming language. An electronic digital computer is designed to follow (execute, carry out) a step-by-step set of binary-coded instructions stored in its memory. A programming language consists of two parts—a *language* and a computer program called a *compiler*. A human programmer writes instructions using the programming language, and a compiler translates the program into the a computer's machine language. Over the years a great many programing languages have been developed. To be used on a specific make and model of computer, a compiler has to be written to do the translation for that type of computer. (Wikipedia, 8/17/2020, link; Computer Science, n.d., link.) The Wikipedia link provides a list of many hundreds of programming languages. Since the development of the first programmable computers, programmers have been working to develop aids to simplify and speed up the tasks involved in writing and debugging programs. (Also see **Assembly language programming, Bug, Computer program (high level programming language), Ada Lovelace.**)

Punch card (Hollerith card). A method of storing data as holes punched in a thin rectangular piece of cardboard, and readable by a card reader. First used by Herman Hollerith in processing

the U.S. Census data of 1890. (Wikipedia, 2020, link.) Now regarded as an historical relic. (Also see **Herman Hollerith**.)

Quantum computer. An ordinary *binary bit* must be either 0 or 1. A *qubit (quantum bit)* can essentially be both 0 and 1 at the same time. A full-scale quantum computer making full use of this technology may be millions of times as fast as today's binary bit-based computers. (Cho, 7/9/2020, link; The National Academy Press, 2019, link to free PDF book.) (Also see **Super computer.)**

Quantum-proof encryption. The speed of a quantum computer will be sufficient to break many of the current encryption methods used on the Internet for guarding the privacy and security of messages, money transactions between banks, etc. In 2016, the U.S. National Institute of Standards and Technology (NIST) announced an open contest to develop quantum-proof encryption. While the winners will not be announced until 2022, the organization announced recently that it had narrowed the initial field of 69 contenders down to just 15. (O'Neill, 8/3/2020, link.)

Quantum supremacy. A time in the future when quantum computers will have become routinely available and reliably able to solve many different types of problems that no current electronic digital computers can solve in any feasible amount of time. In 2019, it was demonstrated that a quantum computer may be millions of times as fast as current computers. (Wikipedia, 2020, link.) A number of companies are working to be the first to produce a reliable, cost effective quantum computer that can be used in a wide variety of problem areas. Many forecasters suggest that this may occur by 2024 or 2025. (IDC, 12/2/2019, link; IBM, n.d., link. This IBM site includes two short videos.) (Also see **Quantum computer.**)

Ransomware. A type of *malware* that cyber criminals use to block you from accessing the data on your computer. If the ransom demands are not met within the cyber criminal's timeframe, the data remains unavailable, or your data may be deleted by the software. (Unitrends, n.d., link.) (Also see **Malware**.)

Remote work. Work (employment) done outside of a traditional office environment. Typically makes use of telecommunication and computer tools. Steady improvements in connectivity make it possible for an increasing number of jobs to be carried out remotely—for example, from one's home or a convenient office space located near home. Many remote workers find it to be more convenient and less expensive to work remotely. Some are able to move outside of high rent areas, lowering their cost of living. (Hadden, et al., 8/17/2020, link; Remote Year, Inc., 2020, link.) (Also see **Online.**)

Rip off. Steal, especially as it applies to computerized content such as music, video, and computer software. (Dictionary.com, 2020, link.) (Also see **Hacking, Plagiarism**.)

Robot (robotics). "Any automatically operated machine that replaces human effort, though it may not resemble human beings in appearance or perform functions in a human-like manner. By extension, *robotics* is the engineering discipline dealing with the design, construction, and operation of robots." (Moravec, 6/3/2020, link.) The Amazon company order fulfillment operations provide a good example of very extensive use of robots. (Also see **Jeffrey Bezos.**)

Scanner (image scanner). A device that optically scans an image, printed or hand-written text, object, etc., in order to produce a digital image of it. In 1913, Édouard Belin received a patent for a device to scan pictures and send the results over a telephone wire. This technology was used in

the AT&T Wirephoto Service developed in the early 1920s, and still was in use until the mid-1990s. (Wikipedia, 2020, link.) People now routinely take pictures using the digital camera built into their smart phones and share them with others throughout the world.

Search engine. A term most often used to designate a computer program designed to search the Web, but may also refer to a program designed to search and make use of a specific database. There are many different Web search engines, but Google Chrome (often just called Google, or the Google browser) dominates this market with nearly 92% of the market. (Oberlo, 2020, link; Price, 4/15/2020, link.) (Also see **Google.**)

Scratch. An educational programming language designed especially for ages 8 to 16, but used by people of all ages. The language was developed by Mitch Resnick in 2003. By 2020, Scratch was being used in more than 150 different countries and available in more than 40 languages. (MIT, 2020, link.) (Resnick, 1/29/2013, link.) (Also see **Logo**.)

Self-driving vehicle. See **Autonomous vehicle.**

Server (computer server). A computer connected to one or more other computers in order to provide online data and services to those computers. Local area networks, wide area networks, and the Web make use of servers. (TechTerms, 416/2014, link.)

Silicon Valley. A region in the southern part of the San Francisco Bay Area in Northern California that has long served as a global center for high technology. Computer chip-manufacturing (which makes use of silicon), and computer-oriented research companies were an important early part of the concentration of high tech companies in this region. (Wikipedia, 2020, link.) (Also see **Chip**.)

Singularity (technological singularity). For years, the capabilities of artificial intelligence have been increasing steadily. A number of years ago, Ray Kurzweil predicted that the capabilities of computer-based AI would far exceed the capabilities of humans by about 2045, and called this event the *Singularity*. (Wikipedia, 2020, link.) He repeats this prediction in a 2018 YouTube video in which he talks about the future of AI. (YouTube, 3/20/2018, link to 61 minute video.) John von Neumann had earlier coined a similar use of the term singularity. (Ulam, 1958, link to PFD file.) (Also see **Ray Kurzweil, John von Neumann.)**

Skype. A Microsoft-owned telecommunications application that specializes in providing a variety of communication services over the Internet. These include video chat and voice calls between computers, tablets, mobile devices, and smartwatches. Skype also provides instant messaging services and supports video conference calls. (Wikipedia, 2020, link.) (Also see **Social networking, Zoom**.)

Slide rule (slider ruler, slipstick). Widely used handheld analog calculation device invented by William Oughtred in 1622. It remained in very wide use until being replaced by electronic calculators and computers in the 1970s. (The Oughtred Society, 12/14/2013, link.)

Smart phone. A mobile cell phone with additional features that can include a digital camera, audio recorder, email and texting capabilities, and many other features. Its large amount of computer storage and processing power provide capabilities similar to those of a microcomputer. A smart phone typically has a touchscreen interface, Internet access, and an operating system capable of running downloaded applications. (Tocci, n.d., link.) (Also see **Cell phone**.)

Smart watch. A touchscreen electronic digital watch with a wide variety of additional features such as monitoring your heart rate, tracking your activity, and providing reminders throughout the day. When interfaced with a smart phone, some smart watches can place and receive phone conversations. (TechTerms, 8/5/2017, link.)

Snapchat/TicTok. Both are video-based social media networks quite popular with younger users. Snapchat, launched in 2011, posts video content that expires either immediately or after 24 hours. TicTok, launched in 2017, posts video content that does not have an expiration feature. In January 2020, Snapchat had more than 210 million daily users globally, while TicTok had more than 800 million monthly active users. (Bump, 1/16/2020, link.) (Also see **Social media**, **Social networking.**)

Social media. Interactive computerized communication networks that individuals and groups use to chitchat and share information, such a photo, text, music, and so on. Typically, a user's profile and identity are stored) by the computer system providing the network services. (Wikipedia, 2020, link.) (Also see **Social networking**.)

Social networking. Networks of people who use Internet-based social media sites to stay connected with other people for social and/or business purpose. There are a huge number of social media sites. (Wikipedia, 2020, link; Jamie, 6/5/2019, link.) The largest is Facebook, with about 2.6 billion users in the first quarter of 2020. (Statista, 2020, link.) The total population of earth in 2020 was about 8.8 billion (Worldometer, 8/18/2020, link.) Based on this data, one can see that about 30-percent of the world's population uses Facebook. (Also see **Facebook, Instagram, Snapchat/TicTok, Social media**.)

Solid State Storage (SSS). A fast, electronic, microchip-based type of computer storage that has no moving parts. Storage and retrieval times are much faster that the use of magnetic tape and disks to accomplish the same tasks. (Rouse, n.d., link.) (Also see **Digital data storage device.**)

Spam. Any kind of unwanted, unsolicited digital communication that gets sent out in bulk. Spam often is associated with efforts to sell products of questionable value. (Malwarebytes, 2020, link.) (Also see **Malware**.)

Spellchecker/grammar checker. Software used with a word processor to check the correctness of both the spelling and the grammar in a written document. As more and more people do their writing using a word processor, this has led schools to reconsider both the importance of having students learn cursive writing, as well as requiring that they develop a high level of skills in spelling and grammar. (Grammarly, n.d., link.)

Spreadsheet. A computer program (software) used to produce an electronic two-dimensional table of numerical, alphabetic, and/or other types of data. This data can be processed by the use of built-in formulas and functions available in spreadsheet software. This software also can be used to create graphs and charts based on this data. (PerfectXL, 2020, link.) The first microcomputer-based spreadsheet software became available on the Apple microcomputer in 1979, and this contributed greatly to the financial success of Apple. (Wikipedia, 2020, link.) In 2020, Microsoft's Excel spreadsheet software is the world's most widely used spreadsheet. (Wikipedia, 2020, link.)

Supercomputer. A term used to describe the world's fastest electronic digital computers. The processing power in these computers consists of many thousands of very fast 64-bit microprocessors. The following is a current (2020) example of a problem needing such compute

power. In the first week of June 2020, the U.S.'s Summit computer (the world's second fastest supercomputer at that time), ran some 2.5 billion correlation calculations across a dataset of 40,000 human genes and 17,000 genetic samples from covid-19 patients. The calculations revealed ten possible therapies that might be useful. (Anderson, 8/2/2020, link.)

In June 2020, Japan's Fugaku supercomputer became operational. At about 2.8 times the speed of the Summit computer, it was ranked as the world's fastest supercomputer. It has a speed of 415 quadrillion floating point arithmetic operations per second. A quadrillion is 10^{15}, which is one thousand million million. (McKay, 6/22/2020, link.) Even this great speed is slow relative to the potential speed of a quantum computer. The 1951 UNIVAC 1 was the first commercially available computer, and it had a speed of 1,000 operations per second. Thus, the 2020 Fugaku supercomputer is 415 million million times as fast as the UNIVAC 1. (History, n.d., link.) (Also see **Quantum computer**.)

Tablet computer. A type of portable (personal) computer that is smaller and has better portability than a laptop computer, but also has fewer features and/or options. It has a touchscreen display, with its battery, display, and circuitry all contained in a single unit. Keyboard entry is via the touch screen. Popular versions include Apple's iPad, Amazon's Fire Tablet, and Samsung's slates. (Britannica, 2020, link; Consumer Reports. 2020, link.) (Also see **Laptop computer**, **Personal computer**.)

Teletype (teleprinter). An electromechanical device that can be used to send and receive typed messages, such as telegrams. Although developed in the late 1830s and 1840s as the first use of electrical engineering, teleprinters were not used for telegraphy until 1887 at the earliest. (Wikipedia, 2020, link.) Teleprinters have largely been replaced by electronic computers and laser printers.

Texting/messaging. Methods of sending key-boarded information to one address or to a group of addresses. Texting/messaging displays the communication immediately on the recipient's receiving device, such as a smart phone or a computer that has appropriate software (for example, Google Voice or Microsoft's Skype) for this task. This is different from using email. Email adds the communication to the receiving device's list of email messages received, but requires that the person open the received document in order to read it. (Khillar, 6/14/2018, link.) There are a variety of texting/messaging systems in wide use. (Also see **Email**, **Instant messaging.)**

3D printer (three D printer.) Computer printer technology designed to use computer-driven printers to create 3D objects ranging from tools, toys, and small sculptures up to airplane wings and concrete houses. 3D printers are sometimes referred to as Maker Machines (Makers Empire, 2020, link.)

Thumb drive (flash drive). A small, easily portable, rectangular-shaped, solid state, digital data storage device that first became commercially available in 2000 (Wikipedia, 2020, link.) The first thumb drive had a storage capacity of 8 megabytes. By 2020, this had grown to a storage capacity of 1 terabyte, or 125 times as much. (Also see **Digital data storage device**.)

TicTok/Snapchat. Both are video-based social media networks quite popular with younger users. Snapchat, launched in 2011, posts video content that expires either immediately or after 24 hours. TicTok, launched in 2017, posts video content that does not have an expiration feature. In January 2020, Snapchat had 210 million daily users globally, while TicTok had more than 800

million monthly active users. (Bump, 1/16/2020, link.) (Also see **Social media, Social networking**.)

Time-shared computing. The BASIC programming language and its implementation on the Dartmouth Time Sharing System was the first commercially successful *time-sharing computer system.* This technology allows many people to simultaneously use one computer. Previously, a programmer used a card punch machine or a paper tape punch machine to store a program on punch cards or paper tape. A computer's card or paper tape reader would input this program into the computer's memory and run (follow the instructions in) the program. This process was speeded up by inputting a sequence of programs into a special computer memory area while the computer was processing one user's program. As soon as the computer finished one user's program, the next program was immediately available for the computer to start running it. This saved computer time. Time-shared computing now allows many individual programmers to simultaneously use keyboard terminals all connected to one computer, as they write, run, and debug their programs. (Wikipedia, 2020, link.) Nowadays, a person using a Web search engine such as Google is one of many thousands of computer users simultaneously making such searches, and their needs are being met by a large number of time-shared computers that are linked together. (Also see **Batch processing, Debug computer software**.)

Touch screen (touchscreen). A combination of a computer display screen and a computer input device technology that one can control by touching it. Tablet computers now commonly use such technology. This idea was first described in papers written in 1965 and 1967 by Eric Johnson, of the Royal Radar Establishment, located in England. (Wikipedia, 2020, link.) It was first widely implemented in the mid 1980s. (Zytronic, 2020, link.) (Also see **Computer stylus**, **Tablet computer.**)

Touchpad (trackpad). The two terms are synonymous. A touchpad is a device that can sense the touch of a finger to control the cursor on a computer screen. The touchpad itself is not a display screen. Apple's PowerBook laptop computer that was introduced in 1994 was the first laptop computer to make use of a touchpad in place of a mouse. (Wikipedia, 2020, link.) (Also see **Computer mouse**.)

Transistor. A semiconductor device used to amplify or switch electronic signals and electrical power. Transistors revolutionized the field of electronics. As a replacement for a vacuum tube, a transistor is smaller, less expensive, uses less power, generates less heat, and has a much longer life. A point-contact transistor was invented by American physicists John Bardeen and Walter Brattain in 1947, while working under William Shockley at Bell Labs. The three of them shared the 1956 Nobel Prize in Physics for their achievement. (Wikipedia, 2020, link.) (Also see **William Shockley**.)

Troll (computer troll). In online discussion and information sharing group communications, a *troll* is a person who posts online comments that are offensive, incendiary, off-topic, and often designed to be deliberately inaccurate or misleading. (TechTerms, 5/3/2011, link.) (Also see **Fake News, Malware.**)

Turing Test. In 1950, Alan Turing published an article discussing what has come to be called the Turing Test. Quoting from the Oppey and Dowe article:

> Turing (1950) introduces the imitation game by describing a game in which the participants are a man, a woman, and a human interrogator. The interrogator is in a room

apart from the other two, and is set the task of determining which of the other two is a man and which is a woman. Both the man and the woman are set the task of trying to convince the interrogator that they are the woman. Turing recommends that the best strategy for the woman is to answer all questions truthfully; of course, the best strategy for the man will require some lying. The participants in this game all use teletypewriter to communicate with one another—to avoid clues that might be offered by tone of voice, etc. Turing then says: "We now ask the question, 'What will happen when a machine takes the part of [one of the people being interrogated] in this game?' Will the interrogator decide wrongly as often when the game is played like this as he does when the game is played between a man and a woman?" (Oppey, G. & Dowe, D., 2020, link.) (Also see **Alan Turing**.)

Tweet. See **Twitter**.

Twitter. American social networking service where users can post and interact with short *text messages known as tweets.* Twitter was created and launched in 2006 by Jack Dorsey, Noah Glass, Biz Stone, and Evan Williams. Tweets initially were limited to a length of 140 characters, but this limit was increased to 280 characters in 2007. (Perez, 101/30/2018, link.) (Also see **Texting/messaging**.)

Undersea cable. The first undersea cables for carrying telegraph signals were laid in the 1850s. These were not very successful because the cable technology of the time was inadequate. The first transatlantic telephone cable went into service in 1956. It was actually two cables, one to carry the eastbound traffic, the other the westbound. This cable carried 36 telephone channels, each of which was the equivalent of 22 telegraph circuits. A call cost about $3 a minute at that time, which would be more than $20 a minute in today's dollars. (Burns, 2012, link.)

Undersea and on land fiber optic cables are in standard use today. (Wikipedia, 2020, link.) In 2019, a transatlantic cable funded by Facebook and Microsoft achieved a speed of 26.2 terabytes per second. This is the equivalent to transmitting more than 5,000 DVDs (5,000 two-hour videos) in one second! (Porter, 2/28/2019, link.)

Video conferencing. A technology that allows users in different locations to hold face-to-face online meetings that include both video and audio. (Investopedia, n.d., link.) Use of video conferencing very rapidly increased in 2020 because of the coronavirus pandemic. It is being used today for school classes, conferences, church services, online medical appointments, concerts and other performances, weddings and funerals, and many other group activities. (Also see **Zoom.**)

Video game (computer game). A game played by one or more persons interacting with a computer, whether through a handheld device, personal computer, or online connectivity. While often thought of only in terms of their entertainment uses, many computer games are designed partly or mainly for educational purposes. One of the early and widely used educational computer games is *The Oregon Trail,* an historical simulation developed by Don Rawitsch in 1971 that still is available in 2020. (94.3 The Point, 2020, link; Science Daily, n.d., link.)

There are a great many educational computer games. (Hopkins, 12/17/2018, link.) Some are considered to be dual purpose—being both quite educational and quite entertaining. Minecraft and Roblox are two widely used examples. (Minecraft, 2020, link; Roblox, 2020, link; Open Education Database, n.d., link.) (Also see **Computer-aided learning**.)

Virtual computer. Consider a computer purchaser or leaser who specifies the hardware, operating system, and other characteristics of a computer, and then has that machine be *constructed* (the components being electronically connected) in a computer center or in several computing centers that house a large number of the needed hardware and software components. The purchaser or leaser obtains the full use of the *virtual computer* (via rental or outright purchase) without having any of its components physically installed at their place or places of business. (Wikipedia, 2020, link.)

Virtual reality. Popularized by the holodeck featured in the Star Trek science fiction television series produced during the 1960s. Virtual reality is a computer-generated simulation of a three-dimensional image or environment that can be interacted with in a seemingly real or physical way by a person using special electronic equipment, such as a helmet with a screen inside or gloves fitted with sensors." (Lexico, 2020, link.)

Voice activated response system (voice assistant system, voice recognition). A voice input system that allows a user to interact verbally with a computer response system. The computer that is activated may range from one connected through the Internet to one located in a nearby children's toy that has a very limited vocabulary and response capabilities.

Apple corporation's Siri became available in 2010, and was the first commercially successful system. (Clockwise Software, 9/2/201, link.) Today, Apple has Siri, Amazon has Alexa, Microsoft has Cortana, and Google has Google Assistant. (The Verge, 5/20/2016, link.)

Such systems are widely used, and gradually are becoming better at using artificial intelligence to understand the intent (the requested service) of the speaker. The requested service may include activities such as turning on or off a particular light in one's home or office, playing a selected piece of music from the computer system's library, changing a TV channel, locking or unlocking a door, providing a weather forecast, and more. One potential disadvantage of the Internet-connected systems is their ability to record conversations that they hear, and these conversations might then be listened to by others who have access to the system.

Voice recognition. A computer system that accepts natural language voice as input and translates it into text. (Kikel, 7/6/2020, link.) This is somewhat like a person speaking to a secretary who takes shorthand notes and then transcribes the notes. With a voice recognition computer system, a user can dictate a document and the computer will translate the voice into text that can be edited on a computer and printed out. However, current voice recognition systems fall short of the ability of a good human secretary who is able to produce documents with correct spelling and grammar, and who also catches and strives to correct errors in content. A high level of computer success in such voice recognition system will require considerably more progress in artificial intelligence.

Voice synthesis. Artificial simulation (production) of human speech by a computer or other device. (Techopedia, 2020, link.) When coupled with a voice input and computer translation system, it now is possible to produce synthesized output in a second language that mimics the voice tonality of the original speakers. Voice synthesis can also be used to have a sample of a person's voice, and then generate faked speech that the person never said. (Also see **Fake news, Malware.**)

Wearable computer. A computing device worn on or implanted in the body. (Wikipedia, 2020, link.)Examples that can be worn on the body include a smart watch and smart glasses. An

implanted device such as an insulin pump is considered to be a wearable computer. (Aleppo, n.d., link.) A device that is carried, such as a smart phone, is not considered to be a wearable computer. (Mikhalchuk, 8/23/2018, link). (Also see **Neural implant**).

Web (World Wide Web). Invented by Sir Timothy John Berners-Lee in 1989, the Web is an information system (a huge database) where documents are identified by Uniform Resource Locators (URLs) and are made accessible by using search engines over the Internet. (World Wide Web Foundation, 2020, link.) Think of the Web as *content*, and the Internet as *connectivity* used to access the Web content and to accomplish other connectivity tasks. We now have Web search engines that can accept voice input for searching the Web, and then produce the search results as voice output (Wikimedia, 2020, link.) (Also see **Internet, Tim Berners-Lee**.)

Webcast. A video or audio event transmitted over the Internet. (Lexico, 2020, link.) Think in terms of a radio or TV broadcast over the airwaves versus a broadcast over the Internet.

Wikipedia. A free online encyclopedia project begun in January 2001, by Jimmy Wales and Larry Sanger. It is owned and managed by the non-profit Wikimedia Foundation. The content is created and maintained by volunteers. Accuracy of new or modified articles is checked by the volunteers. Different versions and lengths of the Wikipedia exist in 300 different languages. As of March 2020, the Wikipedia was attracting about 1.5 billion unique visitors (more than 1/6 of the world's population) per month. The English version is the largest, and had 6,143,340 articles, with a total of about 3.6 billion words, in March 2020. (Wikipedia, 2020a, link; (Wikipedia, 2020b, link.) Quoting from the 2020b Wikipedia reference above:

> There are many other online databases which combine several encyclopedias and encyclopedic dictionaries and allow users to search all of the works simultaneously. One example is Oxford Reference Online—a database of 221 encyclopedias and encyclopedic dictionaries, offering about 1.4 million articles as of 2011, with expansions planned for the future. Another example is Xrefplus, which offers access to 262 encyclopedias, dictionaries, and other reference books. This all added up to about 2.9 million entries when the database had 225 titles. There are also HighBeam Research and GaleNet. GaleNet—which is likely the largest named so far—offers users the ability to search several encyclopedia databases, including the Biography Resource Center (1,335,000 people), Gale Virtual Reference Library (594 reference books), and the Science Resource Center (51 titles), among others.

Wolfram Alpha. A computational knowledge engine (a question-answering engine) developed by Wolfram|Alpha LLC and launched May 15, 2009. Based on Wolfram Mathematica, a computational toolkit that encompasses computer algebra, symbolic and numerical computation, visualization, and statistics capabilities. Its website prompts you to "Enter what you want to calculate or know about" and then provides you with a long list of possible categories that you may find of interest. (WolframAlpha, 2020, link; Wikipedia, 2020, link.) (Also see **Stephen Wolfram**.)

Word processor. The history of typewriters has been traced back to 1575. The first working manual typewriter was built by Pellegrino Turri in Italy in 1808. The first electric typewriters were produced in the early 1900s. (Wikipedia, 2020, link.)

In the late 1960s, IBM developed the Magnetic Tape/Selectric Typewriter, and that led to the development of computer-based word processing in the early 1970s. The microcomputers

produced in the mid-1970s brought word processing to the masses. (Polt, 2015, link; Wikipedia, 2020, link.) Today's word processors include a wide range of features to assist in the production of very well-written documents, including spellcheckers, grammar checkers, a dictionary, a great variety of typeface options, and other aids to producing visually pleasing documents. (Also see **Spellchecker/grammar checker**.)

YouTube. The world's largest online video-sharing platform. It was founded in February 2005, by three former PayPal employees—Chad Hurley, Steve Chen, and Jawed Karim. Google bought the site in November 2006, for US$1.65 billion and it now operates as one of Google's subsidiaries. (Wikipedia, 2020, link.)

YouTube's free services allow users to upload, view, rate, share, report, and comment on videos. Users can create, share, and add to their personal playlists. It also includes some provisions for downloading videos for off-line viewing. (Marshall, 2020, link.) YouTube offers a wide variety of user-generated and corporate media videos. Available content includes video clips, TV show clips, music videos, short and documentary films, audio recordings, movie trailers, live streams, and other content such as video blogging, short original videos, and educational videos. YouTube also offers a paid subscription service that is free of ads. (YouTube, 2020, link.) (Also see **Netflix.**)

Zoom. A widely used video conferencing system founded in 2011, and now one of the most popular of many such systems. It is a for-profit company founded by Eric Yuan. Early versions of videoconferencing became available in the 1930s, but these systems were not commercially available until 1970, when AT&T launched the first true video conferencing system that people were able to access in their business office or at home. (Null, 4/10/2020, link; Wikipedia, 2020, link.). (Also see **Skype**, **Video conferencing.**)

Final Remarks

> "Because education will be much more efficient, it will probably cost less than it does now. This is not a utopian dream. It is well within the range of an existing technology of teaching." (B.F. Skinner; American psychologist, author, advocate for social reform; 1904-1990.)
>
> "We have ignored cultural literacy in thinking about education. We ignore the air we breathe until it is thin or foul. Cultural literacy is the oxygen of social intercourse." (E.D. Hirsch, Jr.; American educator and academic literary critic; 1928-.)

Technological changes are non-neutral—they certainly do not affect all people equally. Some people will benefit much more than do others from computer-related technological changes, while still other people will be disadvantaged. This non-neutral concept can be expanded to the study of all topics that examine changes in our world.

In my opinion, the two greatest human inventions in all of recorded history have been *written language* and the *electronic digital computer*. Each has been a world change agent, strongly affecting the lives both of people who learn to effectively use these human inventions, and those who lack the opportunity and/or decide to not take advantage of such opportunities.

Both of these inventions require considerable effort to learn to effectively use them as aids to solving problems and accomplishing tasks at a contemporary level. With the three R's, the required necessary skill and knowledge level is slow to change over the years. But, with computers and the field of Information and Communication Technology (ICT), learners face a rapidly growing and changing body of knowledge and skills.

An interesting aspect of reading is that graphic images (pictures) used in written material can be understood even by non-readers, and can be used as in aid to learning to read. A person can watch, enjoy, and learn from video without learning to read and write a spoken language.

Similarly, there are many uses of ICT that require very little formal learning on the part of the user. Moreover, there are many uses that require modest learning, but that can solve problems and accomplish tasks that are well beyond what students are learning to accomplish through our current (conventional) school curriculum.

This situation is a large and growing problem in our current educational systems. It certainly is not a problem that can be solved just by just providing students and teachers with the types of information in this *Cultural Computer Literacy for Educators* book. My presenting you with a long list of computer-related people and terms, and you doing the same thing for your students, does not accomplish the goal of improving computer-related cultural literacy. Only when these terms become part of the working and thinking vocabulary used by you and your students will my goal of helping to improve computer cultural literacy have been accomplished.

I have no expectation that teachers and others making use of my lists of people and terms will agree with all of my choices. They may or may not decide to add parts of this historical information to their everyday personal and professional lives. They may or may not be motivated to learn more about specific items I have included in my lists. Moreover, I have not attempted to make a guess at the age level or grade level when it would be appropriate to introduce these ideas students at various grade levels in school.

However, this book can help teachers in all disciplines and at all grade levels to increase their awareness of the changes ICT is bringing to the world. This can help them to identify ICT-related topics that are relevant to their personal needs and to those of the students they teach. I suggest that you talk with your students and other young people about the lists. Ask them for the vocabulary they use in talking with their friends about social networking, computer games, computer uses in school and at-home schooling, and so on.

In closure, I want to thank you and all of my other readers for making use of this book. Now, go forth and make good use of what you have learned!

Additional References and Resources

Arai, N. (April 2019). Can a robot pass a university entrance exam? *TED Talk.* (Video, 13:26.) This talk explains how an AI system was able to pass university entrance exams in Japan without having any understanding of what it was reading and writing. Retrieved 10/10 2020 from https://www.ted.com/talks/noriko_arai_can_a_robot_pass_a_university_entrance_exam.

Barham, J.A. (10/16/2018). The 50 most influential living computer scientists. *The Best Schools.* Retrieved 7/15/2020 from https://thebestschools.org/features/most-influential-computer-scientists/.

Core Knowledge Foundation (2020). Core knowledge. Retrieved 6/29/2020 from https://www.coreknowledge.org/about-us/.

Hirsch, E.D. (1988). *Cultural literacy: What every American needs to know.* New York: Vintage.

International Society for Technology in Education (ISTE) (2019). *2019 annual report.* Retrieved 7/19/2020 from https://www.iste.org/about/iste-story/annual-report.

Marr, B. (9/30,2019). The 7 biggest technology trends in 2020 everyone must get ready for now. *Forbes.* Retrieved 10/8/2020 from https://www.forbes.com/sites/bernardmarr/2019/09/30/the-7-biggest-technology-trends-in-2020-everyone-must-get-ready-for-now/#75f25aeb2261.

Moursund, D. (2020). Computational thinking. *IAE-pedia.*

Moursund, D. (2020). *Information Age Education Newsletters.*

Moursund, D. (2020). What the future is bringing us. The link provides access to annual entries that began in 2007. *IAE-pedia.*

Moursund, D. (2019). Women and ICT. *IAE-pedia.*

Moursund, D. (2018). *La cuarta R (Segunda edición).* Eugene, OR: Information Age Education.

Moursund, D. (2018). *The fourth R (Second edition).* Eugene, OR: Information Age Education.

Moursund, D. (2018). Two brains are better than one. *IAE-pedia.*

Moursund, D. (2017). History of computers in education. *IAE-pedia.*

Rinconada, J. (9/6/2019). Most influential people in computer science. *medium.com.* Retrieved 7/25/2020 from https://medium.com/@jrinconada/most-influential-people-in-computer-science-59fe9461c51b.

Sylwester, R. (2017). 20/20 vision for 2020 challenges. *IAE-pedia.* Retrieved 10/8/2020 from http://iae-pedia.org/.

TED Talks (n.d.). TED and TEDx provide free access to more than 3,500 talks by well-informed, influential people on a very wide range of topics. All of these talks are educational and many are suitable for use in precollege education. Typically, they are under 18 minutes in length. For a list of general categories, see https://www.ted.com/topics. There are 927 talks in the Technology category at https://www.ted.com/topics/technology, 198 talks in the Brain category at https://www.ted.com/talks?topics%5B%5D=brain, 43 talks in the Hacking category at https://www.ted.com/topics/hack, 58 talks in the Intelligence and Artificial Intelligence category at https://www.ted.com/topics/intelligence, and so on.