**Science is not merely a collection of facts, concepts, and useful ideas about nature, or even the systematic investigation of nature, although both are common definitions of science. *Science is a method of investigating nature--a way of knowing about nature--that discovers reliable knowledge about it.* In other words, science is a method of discovering reliable knowledge about nature. There are other methods of discovering and learning knowledge about nature (these other knowledge methods or systems will be discussed below in contradistinction to science), but science is the *only* method that results in the acquisition of reliable knowledge.**

***Reliable knowledge is knowledge that has a high probablility of being true because its veracity has been justified by a reliable method.* Reliable knowledge is sometimes called justified true belief, to distinguish reliable knowledge from belief that is false and unjustified or even true but unjustified. (Please note that I do not, as some do, make a distinction between belief and knowledge; I think that what one believes is one's knowledge. The important distinction that should be made is whether one's knowledge or beliefs are true and, if true, are justifiably true.) Every person has knowledge or beliefs, but not all of each person's knowledge is reliably true and justified. In fact, most individuals believe in things that are untrue or unjustified or both: most people possess a lot of unreliable knowledge and, what's worse, they act on that knowledge! Other ways of knowing, and there are many in addition to science, are *not reliable* because their discovered knowledge is *not justified*. Science is a method that allows a person to possess, with the highest degree of certainty possible, reliable knowledge (justified true belief) about nature. The method used to justify scientific knowledge, and thus make it reliable, is called the scientific method. I will explain the formal procedures of the scientific method later in this essay, but first let's describe the more general practice of scientific or critical thinking.**

**An Introduction to Science**

**Scientific Thinking and the Scientific Method**

**by**

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January, 1997**

Schafersman, D. (1997). An Introduction to Science. Department of Geology, Miami University.

The process of [science](http://undsci.berkeley.edu/glossary/glossary_popup.php?word=science) is a way of building knowledge about the universe — constructing new ideas that illuminate the world around us. Those ideas are inherently tentative, but as they cycle through the process of science again and again and are [tested](http://undsci.berkeley.edu/glossary/glossary_popup.php?word=test) and retested in different ways, we become increasingly confident in them. Furthermore, through this same iterative process, ideas are modified, expanded, and combined into more powerful explanations. For example, a few [observations](http://undsci.berkeley.edu/glossary/glossary_popup.php?word=observe) about inheritance patterns in garden peas can — over many years and through the work of many different scientists — be built into the broad understanding of genetics offered by science today. So although the process of science is iterative, ideas do not churn through it repetitively. Instead, the cycle actively serves to construct and integrate scientific knowledge.

<http://undsci.berkeley.edu/article/_0_0/howscienceworks_18>

# Computer assisted instruction

[Previous (Computer animation)](http://www.newworldencyclopedia.org/entry/Computer_animation)

[Next (Computer graphics)](http://www.newworldencyclopedia.org/entry/Computer_graphics)

**Computer Assisted Instruction** (CAI) refers to an [educational](http://www.newworldencyclopedia.org/entry/Education) system of instruction performed almost entirely by [computer](http://www.newworldencyclopedia.org/entry/Computer). The term,**Computer Based Learning** (CBL) refers to the use of computers as a key component of the educational environment. While CAI and CBL can refer to the use of computers in a classroom, they more broadly refer to a structured environment in which computers are used for teaching purposes. Computer programs allow students to work at their own pace along with direct and individualized feedback. Misconceptions can be corrected as they appear and the students' records and scores are made available to the instructor. The use of computers in the teaching and learning process is an important advance in making the highest quality of education universally available, and thus allowing each person to most fully develop their potential.

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## Computerized Instruction

**Computer assisted instruction** (CAI) includes a variety of [computer](http://www.newworldencyclopedia.org/entry/Computer)-based packages that provide interactive instruction. Some are sophisticated and expensive commercial packages while other applications are simple solutions developed by individuals for a local situation. Since work done in one subject area is difficult to transfer to other subject areas, much time and money needs to be invested toward its development. However, once an application has been set up, the cost per additional student is relatively small. Since fewer face to face lectures and seminars are required, this also places fewer geographical and temporal constraints on staff and students.

Computer assisted instruction can be [Internet](http://www.newworldencyclopedia.org/entry/Internet)-based or run on a personal computer from a CD or DVD. Presentations on computers are particularly suited to subjects that are visually intensive, detail oriented, and difficult to conceptualize. Upper level science courses can benefit the most using the "virtual" cases to illustrate the complex [biochemical](http://www.newworldencyclopedia.org/entry/Biochemistry) processes or microscopic images as well as reducing the need to use animal or human tissue. Since the 1970s, CAI packages have become more advanced, interactive, and attractive multimedia learning experiences.

Computer educational systems typically incorporate functions such as:

* Assessing student capabilities with a pre-test
* Presenting educational materials in a navigable form
* Providing repetitive drills to improve the student's command of knowledge
* Providing game-based drills to increase learning enjoyment
* Assessing student progress with a post-test
* Routing students through a series of courseware instructional programs.
* Recording student scores and progress for later inspection by a courseware instructor.

With some systems, feedback can be geared towards a student's specific mistakes, or the computer can navigate the student through a series of questions adapting to what the student appears to have learned or not learned. This kind of feedback is especially useful when learning a language, and numerous computer-assisted language learning (CALL) programs have been developed. A typical CALL program presents a stimulus to which the learner must respond. The stimulus may be presented in any combination of text, still images, sound, and motion video. The learner responds by typing at the keyboard, pointing and clicking with the mouse, or speaking into a microphone. The computer offers feedback, indicating whether the learner’s response is right or wrong and, in the more sophisticated programs, attempting to analyze the learner’s response and to pinpoint errors.

The term, "Learning Design"[[1]](http://www.newworldencyclopedia.org/entry/Computer_assisted_instruction#cite_note-0), refers to the type of activity enabled by software such as the open-source system LAMS (Learning Activity Management System)[[2]](http://www.newworldencyclopedia.org/entry/Computer_assisted_instruction" \l "cite_note-1) which supports sequences of activities that can be both adaptive and collaborative. Computer-aided assessment (also but less commonly referred to as e-Assessment), ranges from automated multiple-choice tests to more sophisticated systems.

Communication technologies are generally categorized according to whether the activity is done at the same time as others online or not. Asynchronous activities use technologies such as blogs, wikis, and discussion boards. Synchronous activities occur with all participants joining in at once, as with a chat session or a virtual classroom or meeting.

## Development of Interactive Technology

Gradually, since the early 1970s, lecturers and teachers adopted computer assisted instruction for a range of teaching purposes. The challenge of CAI is to understand the strength of the media and how to utilize its advantages fully.

The first general-purpose system for computer-assisted instruction was the PLATO System[[3]](http://www.newworldencyclopedia.org/entry/Computer_assisted_instruction" \l "cite_note-2) developed at The University of Illinois at Urbana-Champaign. The PLATO system evolved with the involvement of Control Data who created the first authoring software used to create learning content. The Science Research Council wrote the first CAI system of Math for K-6. Wicat Systems then created WISE as their authoring tool using Pascal, and developed English and Math curricula for K-6. The very first complete CAI classroom for K-6 students was set up at the Waterford Elementary School in Utah using the Wicat system. The first public CAI classroom with its own layout and design was implemented with the Wicat System by Baal Systems (later known as Virtual Systems) in [Singapore](http://www.newworldencyclopedia.org/entry/Singapore) as a joint operation between Wicat and Baal. It is from this design that all the computer learning centers have evolved.

As rapidly as [technology](http://www.newworldencyclopedia.org/entry/Technology) changes and software advances, there are some design principles that remain constant:[[4]](http://www.newworldencyclopedia.org/entry/Computer_assisted_instruction" \l "cite_note-3)

* Interdisciplinary Teams
* Importance of Content
* Quality Production Values
* Choosing and Understanding an Educational Approach

## E-learning

**E-learning** is an all-encompassing term generally used to refer to computer-enhanced learning, although it is often extended to include the use of mobile technologies such as PDAs (personal data assistant) and MP3 (digital audio) players. It may include the use of web-based teaching materials and hypermedia in general, multimedia CD-ROMs or web sites, discussion boards, collaborative software, e-mail, blogs, wikis, computer aided assessment, educational animation, simulations, games, learning management software, electronic voting systems and more, with possibly a combination of different methods being used.

Along with the terms "learning technology" and "educational technology," the term is generally used to refer to the use of [technology](http://www.newworldencyclopedia.org/entry/Technology) for learning in a much broader sense than the computer-based training or computer aided instruction of the 1980s. It is also broader than the terms "online learning" or "online education," which generally refer to purely web-based learning. In cases where mobile technologies are used, the term "M-learning" has become more common. E-learning may also refer to educational web sites such as those offering worksheets and interactive exercises for children. The term is also used extensively in the business sector where it generally refers to cost-effective online training.

E-learning is naturally suited to [distance learning](http://www.newworldencyclopedia.org/entry/Distance_learning) and flexible learning, but can also be used in conjunction with face-to-face teaching, in which case the term "blended learning" is commonly used.

In higher education especially, a Virtual Learning Environment (VLE) (which is sometimes combined with a Managed Information System (MIS) to create a "Managed Learning Environment") may be established in which all aspects of a course are handled through a consistent user interface standard throughout the institution. Established universities, as well as newer online-only colleges, may offer a select set of academic degree and certificate programs via the Internet at a wide range of levels and in a wide range of disciplines. While some programs require students to attend some campus classes or orientations, many are delivered completely online. In addition, universities may offer online student support services, such as online advising and registration, e-counseling, online textbook purchase, student government, and student newspapers.

## Computer Learning Debate

Since its inception, Computer Based Learning has been a subject of close scrutiny and debate, with myriad arguments being advanced both in support of and against it.

Those skeptical of the value of CBL have often argued that it can only teach to its programmatic limitations; that it is not as good as having a human teacher because it can only answer questions which have been programmed into it. In addition, critics such as Neil Postman[[5]](http://www.newworldencyclopedia.org/entry/Computer_assisted_instruction" \l "cite_note-4) have argued that a curriculum with a computer at its core teaches a "technocratic" belief system, making all education into an uncritical type of vocational training. Rather than developing the more generalizable skills of reading, writing, and critical inquiry, the prominent use of computers in the classroom teaches how to manipulate the [technology](http://www.newworldencyclopedia.org/entry/Technology) to elicit the desired response in a non-collaborative, non-rational manner.

In contrast, CBL advocates such as Jonathan Bishop believe that the use of computers in education can lead to social justice[[6]](http://www.newworldencyclopedia.org/entry/Computer_assisted_instruction" \l "cite_note-5) and can be successful when weblogs are used as reflective learning logs.[[7]](http://www.newworldencyclopedia.org/entry/Computer_assisted_instruction#cite_note-6). Also among the arguments advanced by the proponents of CBL is its ability to provide quantifiable and instantaneous feedback for its users. In particular, Computer Based Learning is often seen as the most efficient and effective manner in which to conduct [distance education](http://www.newworldencyclopedia.org/entry/Distance_education), as a lesson plan can be created that allows people to study at their own pace, either via the [Internet](http://www.newworldencyclopedia.org/entry/Internet) or software installed on individual computers at various sites.

Some advocates of Computer Based Learning suggest that the best use of CBL is alongside a more traditional curriculum, playing a supplementary role, facilitating interest in a topic while developing the technical and informational skills CBL promotes. Companies and schools now providing CBL products have often taken this approach in creating and promoting their educational services:

Creating exceptional learning opportunities as well as a change in delivery of instruction requires following a path that involves various stages of disequilibrium, reflection, and continuous improvement.[[8]](http://www.newworldencyclopedia.org/entry/Computer_assisted_instruction#cite_note-7)

## Notes

1. [↑](http://www.newworldencyclopedia.org/entry/Computer_assisted_instruction#cite_ref-0) [E-Learning Strategies, Learning Theory, Instructional Design, Web Design](http://www.epiclearning.com/exchange/design.asp#lt), *E-Learning Exchange/Design*. Retrieved December 8, 2006.
2. [↑](http://www.newworldencyclopedia.org/entry/Computer_assisted_instruction#cite_ref-1) [Learning Activity Management System](http://rds.yahoo.com/_ylt=A0SO5pzXBHpFKxkBHQm7lcYF;_ylu=X3oDMTE1aGsxdW9sBGNvbG8DZQRsA1dTMQRwb3MDMgRzZWMDc3IEdnRpZANTUE9UXzE-/SIG=11ln6681e/EXP=1165710935/**http%3a/www.lamsinternational.com/), *LAMS Learning Activity Management System*. Retrieved December 7, 2006.
3. [↑](http://www.newworldencyclopedia.org/entry/Computer_assisted_instruction#cite_ref-2) [Plato](http://thinkofit.com/plato/dwplato.htm#plato), *PLATO: The Emergence of Online Community*. Retrieved December 8, 2006.
4. [↑](http://www.newworldencyclopedia.org/entry/Computer_assisted_instruction#cite_ref-3) Allison Druin, and Cynthia Solomon, *Designing Multimedia Environments for Children*, (John Wiley & Sons, March 1996 [ISBN 0471116882](http://www.amazon.com/dp/0471116882?tag=encyclopediap-20&camp=14573&creative=327641&linkCode=as1&creativeASIN=0471116882&adid=0NQQZXQ96PDAJGB1J8XS)).
5. [↑](http://www.newworldencyclopedia.org/entry/Computer_assisted_instruction#cite_ref-4) [The Neil Postman Information Page](http://www.neilpostman.org/), *The Neil Postman Information Page:Books, Online Articles, Audio, Bibliography, Related Books*. Retrieved December 8, 2006.
6. [↑](http://www.newworldencyclopedia.org/entry/Computer_assisted_instruction#cite_ref-5) [Achieving Social Justice Through E-Learning](http://www.jonathanbishop.com/Weblog/Display.aspx?Item=89) retrieved December 7, 2006 from *Jonathan Bishop - Official Website*
7. [↑](http://www.newworldencyclopedia.org/entry/Computer_assisted_instruction#cite_ref-6) [Will the Net Generation embrace Blended Learning?](http://www.jonathanbishop.com/Weblog/Display.aspx?Item=99), *Jonathan Bishop - Official Website*. Retrieved December 7, 2006.
8. [↑](http://www.newworldencyclopedia.org/entry/Computer_assisted_instruction#cite_ref-7) Andrea R Gooden, *Computers in the Classroom: How Teachers and Student Are Using Technology to Transform Learning*.

COMPUTER-AIDED INSTRUCTION

Douglas N. Arnold

I. Introduction

Computer-Aided Instruction (CAI), diverse and rapidly expanding

spectrum of computer technologies that assist the teaching and learning

process. CAI is also known as computer-assisted instruction. Examples

of CAI applications include guided drill and practice exercises,

computer visualization of complex objects, and computer-facilitated

communication between students and teachers. The number of computers in

American schools has risen from one for every 125 students in 1981 to

one for every nine students in 1996. While the United States leads the

world in the number of computers per school student, Western European

and Japanese schools are also highly computerized.

II. Types of CAI

Information that helps teach or encourages interaction can be presented

on computers in the form of text or in multimedia formats, which

include photographs, videos, animation, speech, and music. The guided

drill is a computer program that poses questions to students, returns

feedback, and selects additional questions based on the students’

responses. Recent guided drill systems incorporate the principles of

education in addition to subject matter knowledge into the computer

program.

Computers also can help students visualize objects that are difficult

or impossible to view. For example, computers can be used to display

human anatomy, molecular structures, or complex geometrical objects.

Exploration and manipulation of simulated environments can be

accomplished with CAI-ranging from virtual laboratory experiments that

may be too difficult, expensive, or dangerous to perform in a school

environment to complex virtual worlds like those used in airplane

flight simulators.

CAI tools, such as word processors, spreadsheets, and databases,

collect, organize, analyze, and transmit information. They also

facilitate communication among students, between students and

instructors, and beyond the classroom to distant students, instructors,

and experts.

CAI systems can be categorized based on who controls the progression of

the lesson. Early systems were linear presentations of information and

guided drill, and control was directed by the author of the software.

In modern systems, and especially with visualization systems and

simulated environments, control often rests with the student or with

the instructor. This permits information to be reviewed or examined out

of sequence. Related material also may be explored. In some group

instructional activities, the lesson can progress according to the

dynamics of the group.

III. Advantages and Disadvantages

CAI can dramatically increase a student’s access to information. The

program can adapt to the abilities and preferences of the individual

student and increase the amount of personalized instruction a student

receives. Many students benefit from the immediate responsiveness of

computer interactions and appreciate the self-paced and private

learning environment. Moreover, computer-learning experiences often

engage the interest of students, motivating them to learn and

increasing independence and personal responsibility for education.

Although it is difficult to assess the effectiveness of any educational

system, numerous studies have reported that CAI is successful in

raising examination scores, improving student attitudes, and lowering

the amount of time required to master certain material. While studyresults vary greatly, there is substantial evidence that CAI can

enhance learning at all educational levels.

In some applications, especially those involving abstract reasoning and

problem-solving processes, CAI has not been very effective. Critics

claim that poorly designed CAI systems can dehumanize or regiment the

educational experience and thereby diminish student interest and

motivation. Other disadvantages of CAI stem from the difficulty and

expense of implementing and maintaining the necessary computer systems.

Some student failures can be traced to inadequate teacher training in

CAI systems. Student training in the computer technology may be

required as well, and this process can distract from the core

educational process. Although much effort has been directed at

developing CAI systems that are easy to use and incorporate expert

knowledge of teaching and learning, such systems are still far from

achieving their full potential.

IV. History

In the mid-1950s and early 1960s a collaboration between educators at

Stanford University in California and International Business Machines

Corporation (IBM) introduced CAI into select elementary schools.

Initially, CAI programs were a linear presentation of information with

drill and practice sessions. These early CAI systems were limited by

the expense and the difficulty of obtaining, maintaining, and using the

computers that were available at that time.

Programmed Logic for Automatic Teaching Operations (PLATO) system,

another early CAI system initiated at the University of Illinois in the

early 1960s and developed by Control Data Corporation, was used for

higher learning. It consisted of a mainframe computer that supported up

to 1000 terminals for use by individual students. By 1985 over 100

PLATO systems were operating in the United States. From 1978 to 1985

users logged 40 million hours on PLATO systems. PLATO also introduced a

communication system between students that was a forerunner of modern

electronic mail (messages electronically passed from computer to

computer). The Time-shared Interactive Computer-Controlled Information

Television (TICCIT) system was a CAI project developed by Mitre

Corporation and Brigham Young University in Utah. Based on personal

computer and television technology, TICCIT was used in the early 1970s

to teach freshman-level mathematics and English courses.

With the advent of cheaper and more powerful personal computers in the

1980s, use of CAI increased dramatically. In 1980 only 5 percent of

elementary schools and 20 percent of secondary schools in the United

States had computers for assisting instruction. Three years later, both

numbers had roughly quadrupled, and by the end of the decade nearly all

schools in the United States, and in most industrialized countries,

were equipped with teaching computers.

A recent development with far ranging implications for CAI is the vast

expansion of the Internet, a consortium of interlinked computers. By

connecting millions of computers worldwide, these networks enable

students to access huge stores of information, which greatly enhances

their research capabilities.

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