

MYTHS ABOUT TEACHING WITH COMPUTER

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We have to bring the entire human race, without exception, up to the level of semiliteracy of the average college graduate. This represents what may be called the "minimum" survival level; only if we reach it will we have a sporting chance of seeing the year 2200 - Arthur C. Clark.

Computer-assisted instruction is an attempt to achieve "interactive" teaching in an automated fashion. Where it succeeds, the resulting program could be made available to a vast number of people, like a successful movie.

History

Use of the computer as a tool for problem solving in education began in graduate schools about 1955, and a few years later moved into the classroom with the initiation of curriculum development projects in engineering and sciences. Computers used as a teaching machine date from 1958; early developments took place at IBM's Watson Research Center, Systeme Development Corporation, and the University of Illinois (PLATO) Coordinated Science Laboratory. The topic of computers in education became popular in 1965. In the following years of rapid growth, major conferences were organized for computers in mathematics teaching, chemistry education, computer science education, science education, under-graduate curriculum, and high-school counseling.

Kinds of Use

Computer assistance in learning and teaching has been described by many different phases. One could follow the word COMPUTER with two terms, one from each of the following lists :

- Aided
- Assisted
- Augmented
- Based
- Extended
- Managed
- Mediated
- Monitored
- Related

uses in

**Training
Instruction
Learning
Teaching
Education**

The most common label is **CAI**: Computer Aided Instruction.

Areas of Use

The most popular areas of computer assistance in learning and teaching are as follows :

- Occupational industrial training
- College
- Trade school
- Military careers
- Other user characteristics

Goals and Means

The education establishment is large and growing. It consumes a significant percentage of society's energy while delivering a service at growing cost and often of deteriorating quality.

It is a fact that in our country, student population is continuously increasing.

The situation is very similar in other countries, the absolute values being different but maintaining the relative values for the student population growth rates.

Moreover, the increase in knowledge during the last years is as important as the students' population rise, or more so. In many advanced industries most of the products being sold to-day were unknown only ten or fifteen years ago. Up to date studies estimate that the world's printed information is being duplicated every ten years.

This rise in knowledge to be taught, and the parallel rise in people needing to

learn show an insufficiency in the traditional teaching requirements. There are two reasons for it:

First, it is not possible to train the teachers as fast as we need them, and

Second, it is very hard to get the necessary resources to fulfil the requirements of students' places.

Moreover, failures in the educative system, affecting society and teachers, as well as students, are found.

The above considerations-quantitative and qualitative-show that a "Teaching Technology" covering the following fields, is needed :

- Learning processes analysis
- Study of the optimum time to present to the students the information and exercises assuring the optimum comprehension and retentive possibilities
- To design the technical devices for accomplishing the individual capabilities and aptitudes of students (individually prescribed instruction).

In the future, we hope that teachers will be able to use this technology. They will become "Teaching Engineers" and they will be devoted to the designing and planning of special technical devices to bring about the previous goals economically.

An important help to this technology may be informatics. In education, as in other fields, computers can be used in two different ways:

- * As a tool to improve the teaching management.
- * As a direct help for a certain automation of the learning process.

The first way does not differ essentially from the application of computers in Business Administration.

The second way is a much more technical application and a detailed consideration is needed.

Some characteristic factors must be taken into account :

- Low standard of living,
- Irregular distribution of population: highly populated towns and large country areas with low population density,

- Many people having a poor standard of instruction,
- Insufficient number of teachers to fulfil the social demand on them.

However, computer cost are decreasing even while capabilities are increasing. When the computer system is appropriate for educational uses the programs are properly written, the learners should find the following assistance and/or advantages :

- . The availability of multi access systems makes it possible to instruct a large number of students on an individual basis for the first time.

- . It is responsive to individual needs.

- . Because of its capability to branch and to evaluate responses, CAI provides each student with best sequence of instructional material according to his or her skill.

- . Computer is the utmost patient teacher with slower students, adapting its behavior to their individual rates of learning.

- . It is accurate in assessment of answers and solutions.

- . It is individualized in a useful way.

- . It is realistic in the presentation of training or testing situations.

In addition to some of the above mentioned CAI advantages, prepackaged self-instruction can be replaced by a dynamic information system that serves as a common working ground for a scholar and a learner; they share a computer-based, primary-source "textbook", continually updated by the scholar and occasionally annotated by each student who uses it.

Different Conceptions of Computer Assisted Instruction

The users may work individually or in groups/teams, using a device directly connected to a computer (on-line) or using some medium later entered into a computer (off-line). There are many options that vary in convenience and cost. Some of the typical labels are as follows :

Drill and practice system : Computer is an additional help to the traditional lecture. It is used to create practice in exercise solving, by using repetition.

Dialogue (inquiry) : The student, in front of a terminal, can ask the computer for information to help him in solving his problem. The student, in this mode, can prescribe his own sequence of learning.

Problem solving : The student must know a programming language. The computer provides partial solutions. It is mainly used at the university level.

Tutorial : The computer presents curricula material to a student. The branching of the machine to adapt the instructional material to the individual is based on the student's answers referred to as "constructed response". Teachers have to know the programming language and a teaching strategy is built up using generative rules. Students use a natural language.

Simulation : The computer is used to simulate real phenomena (physical, economical, etc.), described in a model in digital computers. This model is expressed by a mathematical algorithm. A student's thought can be explored with this strategy.

Author's method : The texts are chosen by means of an appropriate algorithm; problems are proposed using parameters generated randomly.

Computer managed instruction : The machine, through adequate questions, discovers the standards of knowledge of the student and accordingly sends him appropriate messages giving some indications on the activities to perform, before the next work session on the terminal. Among these activities we can find : to study a specific topic, to listen to a record, to watch an educational film, etc.

Computer used for vocational training : It is very similar to the model just mentioned, but its aim is different.

Teachers/instructors find computer assistance valuable for keeping accurate records :

- summarizing data
- projecting student-learning difficulties
- assembling individualized test
- retrieving information about films or other learning resources.

The strategies

First of all we are going to discuss different strategies and the aspects to be focused before selecting one of them.

There are basically four different class of programs:

- Skinner's Program**
- Pressey's Program**
- Crowder's Program**

Kay's Program

Skinner's programs are characterized by an absolutely linear sequence in the presentation of concepts. The student giving a correct answer to a question on the concept n , is led to the next concept $n+1$, etc. If he is wrong the instructional device shows him the right answer and the student passes to the next concept.

Pressey's program is based on a different idea. The student must choose among several possible answers; but he is only allowed to vary on with the following concept, if the correct answer has been given.

In Skinner's and Pressey's programs no remedial material is offered to the students when they are wrong.

In **Crowder's** strategies student must also chose among several possible answers, but if he does not find the correct one, he is addressed to a different program area, where additional explanations are given according to the nature of his mistake. Afterwards he either can go back to the start point or eventually receive more additional explanations. Succesive branches from each point can make the program as sophisticated as the author desires.

In **Kay's** program several categories of levels are provided for the different concepts. If a mistake has been made in concept n the student will be switched from this concept to the concept $n+1$, through a more detailed way.

The last two groups of programs present remedial material to the student.

Many other kinds of programs have been developed, but they are essentially a combination of the above mentioned ones. From these considerations it can be thought that a lot of different ways to build a program are at our disposal. This is true, but some basic characteristics, common to all the programs, simplify drastically the general scope of this problem. Those characteristics are the following:

- .The material to teach is divided into very elementary parts (frames).
- .We are obliged to check the student's knowledge by means of an adequate question before allowing him to continue the process.
- .The answer given is immediately reinforced by presentation of the correct one.
- .The elementary parts are assembled adequately.
- .The program must follow a learning pattern and be able to explore the amount of knowledge of each student and the retentive time, that is to say, the time during

which student keeps the knowledge.

.The program must use a language as near as possible to the student's one. So an interface between the student and the machine is needed.

Before beginning the preparation of a program some important aspects are to be considered:

* Goals determination, that is to say, kind of tasks to be accomplished by the student at the end of his training cycle.

* Task analysis.-This point brings us to the analysis of the transfer problems, as follows:

Theoretical knowledge $\xrightarrow[\text{Function}]{\text{Transfer}}$ How to solve a problem.

* Concepts imbrication.-If the concepts are independent linearly, the form of presentation is not important; but if they are interrelated the optimum sequence of presentation must be previously decided.

Three elements are to be considered in a CAI system:

- Multiaccess central processor
- Terminals, and
- Author's language

These three elements are not independent, but dynamically related. The central processor is used to store and present instructional material, analyze student responses and make adequate branching. It is also responsible for computing statistics of the time needed by the students to give their answers and the quality of them. The terminals are the interface between the student and the central processor and must allow the students the access to the full system capability. The author's language is a user oriented language enabling the teacher easy preparation of the course and its storage in the system. The same language will control the calling of the educational material by the students and its display at the terminals.

Approaches

The traditional way of programmed instructions is built into an implicit logic of instruction, such as the following sequence;

* The computer program presents information to the student.

* The computer program then asks a question and waits for a response from the

student.

* The program scans a short textual response and classifies the response as right or wrong according to the key words identified within it.

* And if the student's response matches an anticipated wrong answer, the program displays a corrective hint, and if nothing is recognized, it offers a general hint.

An Example

Teaching logic of "extrapolation of number rows", heuristic program.

Problem : I have a sequence of numbers in mind with a certain regularity. I will tell you the first three numbers of my sequence. (This is a typical IBM aptitude test). Then, by marking a sensible guess, you should try to discover which number in my sequence should come in the open place.

5	15	30	...
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The help problem (presented after the second request for help) consists of typing the number that should come in the place of the dots. The two subsequences are given as a help.

5	15	30
+10	+15	+
x3	x2	x

As soon as the main or help problem has been presented, the list of problem-specific expected answers (numbers that could be typed by the pupil and for which there is a preconstructed or "specific" feedback message by the program-author) is read in by the general controlling program. The expected answers are of three kinds:

- * Plausible (sensible) answers
- * Incorrect answers
- * The correct answer

With the feedback on the plausible answers, the pupil is informed that he has given a sensible answer, but : "The sequence I have in mind has a different regularity; try it again."

Summarizing, the main advantages of this technique are.

* The availability of multiaccess systems makes it possible to instruct a large number of students on an individual basis for the first time.

* The CAI ensures the active participation of every student.

* The CAI provides an immediate answer reinforcement.

* Because of its capability to branch and to evaluate responses, CAI provides each student with the best sequence of instructional material according to his skill.

* Computer makes available statistical information on every student, showing which one needs special assistance to improve his learning standard.

System configurations

There are three main configurations based on the form in which the system functions are allocated.

* Totally centralized system.

All the functions are controlled by the central processor. The language is resident in the central processor and all the terminals have access to it. The instructional materials are stored in the main memory and in auxiliary stores.

* Decentralized system.

It is a system having several independent computers, directing each of them their own terminals.

* Centralized system with decentralized operation.

The course data base is managed by a central processor, the instructions being executed by local processors.

Occupational/Industrial Training

Today there is hardly an area of human learning which is not taught in industry. Although the students are all adults, the range of educational offerings extends down to basic skills usually associated with the elementary grades and up to university-level courses both in technical areas and in areas such as humanities, philosophy, and psychology. A listing of courses can only be illustrative, but it would not be unusual to find employees in industry involved in learning to do such things as these :

- To read simple instructions and follow written directions.
- To sell the products and service their companies offer, such as life insurance, heavy machinery, computer services, soap, etc.
- To test, maintain, and repair products and equipment.
- To make business decisions about their company's investments and its actions in the marketplace.
- To supervise employees in accordance with a particular management philosophy.
- To establish long-term organizational goals in relation to national/international problems such as hunger, education, poverty, and pollution.
- To mature intellectually and emotionally as individuals, and to develop insight about themselves and their relationship with other people.

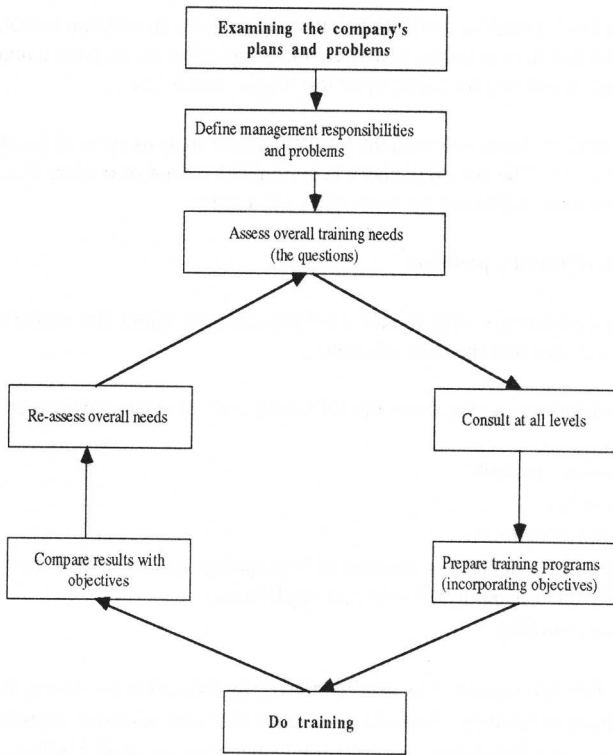
Industrial courses differ not only in subject matter but in many other ways. Some courses take less than an hour to administer. Others, such as apprentice programs and executive management courses, may require months or years. Courses also differ in format. "**on-the-job-training**" usually consists of an experienced employee working with an inexperienced employee in an informal one-to-one relationship. "**Classroom training**" usually suggests an instructor lecturing to a large group of employees. "**Seminar training**" involves a small group of employees with a group leader. However, "**programmed instruction**" as we have seen before, provides for individualized learning on an organization-wide basis, which is the best.

However, to come up with a good programmed training, different types of study/analysis are necessary. See the following figure.

Problems in using computers in education

There are several important problems related to the application of computers in education.

- * Man-machine communication problem.
- * The cost-efficiency problem.
- * The user acceptance problem.



Man-machine communication problem

Two main factors are the source of trouble in the man-machine interrelations. These troubles being: first, the language understood by the machine is not always convenient to the user. Second, The commercialized terminals are not always suitable for educational purposes. For example, the most popular input/output device, the teletypewriter is very noisy and slow. The CRT (cathodic ray tube) is not noisy but has not always a good resolution and it is hard to work with it for a long time. The development of sound records controlled by computer is just beginning today.

Man-machine languages are receiving special attention to-day. Solutions as the "query languages" constituted by a subset of the English language involve difficulties, because it requires too much effort to learn a "query language" specially for younger students.

Moreover, the practical problems related to the automatic language processing are very complex. It is known that by successive imbrications it is possible to bu-

ild sentences long enough to avoid their automatic analysis. In addition to that, it is to be considered that the extension of a vocabulary can generate so great a number of combinations, exceeding the capacity of the biggest machines.

Nevertheless the research on the production and analysis rules of the language may be a good way. The human memory being limited, cannot store more than a finite number of sentences; that is why those rules must exist.

Cost-efficiency problem

Cost analysis is a very widely used procedure to select alternative systems with the lowest cost and the best efficiency.

In educational applications the following cost are to be considered:

- * System element
- * Terminals
- * Communications
- * Development and maintenance of high quality material and of the required software to support the different applications.
- * Compatibility

The first and second costs may be drastically reduced in the future, due to the achievements in technology. However a reduction in communications costs is not expected in the future. Point four is an important cost factor, as about 100 hours of author's time are necessary to prepare one hour of student work at the terminal. The compatibility cost is another important factor of the CAI-systems, because it is difficult that programs oriented to a certain machine could be run on another computer. The program preparation is a very important investment and has to be charged to a considerable number of students. If not, education with computers becomes economically prohibited.

Benefits of a CAI program are much more difficult to be estimated than costs. It is really very questionable to express in money the improvements got by a group of students following a CAI course compared to the traditional methods.

Moreover, experiments carried out have not showed a clear superiority of CAI over classical teaching.

Perhaps future development will be oriented to decrease the computer presentation function and to increase the multimedia approach, keeping computer for an interactive role in the learning process.

User acceptance problem

We can consider two categories of users:

- * The educational staff
- * The students

The users of the first category, mostly teachers are not manufacturers of computer systems (unhappily for them!) and however it is very important their participation in system design. Accordingly actions directed to give the basic ADP training to teachers become more and more necessary. A good way to start with, is the availability of remote terminals allowing the school staff to try the real advantages of a CAI system and giving facilities for a training process.

Student's acceptance is generally good if some important points are guaranteed. The first one is to draw the student's curiosity to this new method; and second, to make students confident that computer is an effective educational help, acting as an examination board.

Summarizing the above ideas we arrive at the following myths about CAI

Myth : You must choose between direct and adjunct use of the computer.

Literature about the computer in learning has correctly stressed that the computer can be used in two ways. Either students can do their own programming, using the computer as an intellectual tool--sometimes called the, adjunct use--or students can interact with teaching programs prepared by others--the direct or mainline use. However, much literature tends to go beyond this, stating or implying that a choice must be made between these two. During the past three years some major developments in educational computing have chosen between the two uses, making it difficult, either because of equipment or socio-political factors, to engage in the other approach. I see absolutely no reason why a teacher should be obliged to make ways, and so neither need be ruled out on philosophical grounds. The same can be said about the many types of dialogues, interactions between teacher and student via the computer. Probably certain types will prove to be efficient for particular subject matter areas, whereas other subject matter areas may require different kinds of dialogues.

Myth : You must have massive equipment to use the computer in education.

Some of the more interesting teaching applications have come from schools with minimal computer equipment. Small stand-alone PC's certainly do rule out some of the kinds of things that can be done. Thus, dialogs are not possible on small PC's; but many other types of usage are possible. The idea persists that one can start only at the level of huge installations, but innovative teachers have shown it to be wrong many times.

Myth : One language is much easier to learn than another.

When students write programs for problems in physics or mathematics courses, the questions of which language to use and how students learn that language become important. Arguments are often based on easy learning of one language or another; thus proponents of BASIC often claim that it is very easy to learn. My own experience indicates that the way the language is taught is much more important than the language itself in determining speed of initial learning. If a reasonable subset is picked, and if reasonable ways are used to introduce the language to students, almost all commonly used languages are relatively easy for beginning students to learn and to use. In my opinion, differences between initial learning ease have been much exaggerated.

Myth : Computers will be widely used in education in present organizational structures of institutions.

New educational developments are often assumed to fit into existing institutional structures. However, it appears to me that the computer is almost certain, in the long run, to revolutionize the organization of schools and universities. The ability to provide learning materials at any time and at any pace, and provide self-testing features, the ability to respond individually to students, to have access to large amounts of data, all imply that the way schools operate are likely to change drastically when computers are widely used in learning.

Myth : Computers are too expensive to use in teaching.

This issue is one of bookkeeping. With any new technology it is hard to know how to calculate costs, and computer centers in practice do this in quite different ways. Furthermore, it is hard to make comparisons with the costs of other components of education, since these often reflect very different types of bookkeeping.

The computers are now competitive with other teaching methods.

Regardless of what one thinks about the costs today, the future situation is clear: of all the costs involved in the educational process, computer costs are almost the only ones going down. Teachers, books, buildings, and films are going up in cost, while computer costs, because of a rising curve of technological development, are still diminishing dramatically; so the computer will become more and more competitive as a teaching device over the next few years.

Myth : If we acquire a CAI language, that solves our problems.

Many computer center directors take the approach that if some language is available (i.e., and the computer in an operational form) for assisting teachers in deve-

loping student-computer dialogues, they have discharged their duties to the teaching community.

Experience in many teaching applications shows, however, that the availability of a dialogue language, no matter how good the language may be, is only a small part of the process of getting reliable and educationally useful teaching materials on the computer. The whole problem of an authoring system--the way one persuades teachers to write materials, the full facilities provided, the incentives for doing this, the use of secretaries, programmers, and other kinds of auxiliary people, the testing procedures, the gathering of feedback, and the preparation of suitable computer--related text material--is enormously more important than the question of the language itself.

Myth : Valid educational material can be developed without involving experienced teachers in the area.

Teaching is still teaching whether done by computer or by any other device. My experience shows that really effective educational materials are still coming, in spite of talk to the contrary, almost entirely from those who are very much involved in the teaching process. The intellectual structure of every discipline is different, and the tough question of fundamental goals, cannot be resolved in any simple, quick way. While computer scientists and educational psychologists can help develop learning material, I do not believe they can do it alone.

Myth : The computer used educationally uses only minor amounts of computer resources.

It is often said that student use of computers requires little core, and little CPU time. While some materials exist for which this is the case, many existing examples indicate quite a contrary situation. Some of our more effective teaching programs at Irvine are very long--some are more than 200,000 words in length and so depend heavily on overlay structures. And some are extremely demanding of the computer in terms of computational and I/O facilities. In some cases these demands exceed the abilities of current time sharing, and so some programs look toward faster systems of the future. So planning for computer uses in teaching under the assumption that minimal computer resources are required is dangerous.

One undoubtedly could proceed a bit further from these myths to other commonly held misconceptions. But I have indicated some of the more important ones to take into account for the future. In spite of these myths, the future is promising for the computer as a learning device.

Conclusions

* The range of disciplines involved in the subject will guarantee a breadth of vision in its students.

Pragmatics : anthropology, social psychology, psychology (especially of language), aspects of linguistics;

Semantics : many aspects of philosophy (especially of ontology, epistemology, scientific method, and philosophical logic), theory of measurement and parts of statistics.

Syntactics : formal logic, some parts of mathematics, and aspects of computer science;

Empirics : statistical communication theory, experimental psychology and aspects of control theory.

* At present CAI research and CAI centres are considerably more developed in United States than in the rest of the world, but its development was based in a very high standard of economical potentiality not always applicable to other countries.

* Governments have to encourage research in this field giving a clever orientation to it, avoiding to waste more money than strictly needed.

* There are too many CAI languages having important impact on the compatibility cost factor. Accordingly effective actions for standardization must be taken at national and international level.

* Many efforts must be done to implement the best computer assisted instruction modalities for the sake of developing countries.

* An international organization should sponsor the research and actions in the application of computers to education. Any duplication of efforts must be avoided and effective interchangeability of experiences among the different countries has to be assured without limitation.

* Medium and small size computers, specifically oriented for educational purposes should be designed on an economical basis.

* In future CAI research should be oriented to the following aims:

- Learning process essence
- Rules to design and construct programs
- Teaching machines
- Multimedia approaches

- Determination of optimum response modalities for each kind of teaching.

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