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ABSTRACT

An "educational utility" providing a cost effective educational delivery system using both management science and technology has been designed. Researchers postulated requirements for a learning system, developed a self-instructional system based on them, and implemented a pilot system. The system, Audiographic Learning Facility (ALF), consists of a Memory for storing and transmitting materials to learners, guided by a Preceptor. The learner exercises on-line control and other control by interposing a human tutor between himself and Preceptor. Scheduled and on-demand modes are available to groups or individuals. The semiotic content of Memory has been defined, a model of the self-instructional process developed, units of learning materials specified, Preceptor elements identified, and a physical facility implemented. Ithas been found that: 1) the learning units are superior to live instruction; 2) an index to structure and content can be devised; 3) self-diagnosis testing and revision are feasible; 4) the system is economical; and 5) students and teacher reaction is favorable. Given this, one can perceive a self-instructional system involving a vendor supplying learning systems, a tutor guiding learners, and a learner who interacts with the vendor's system. (LB)

A Research Report and Prospectus

SELF-INSTRUCTION SYSTEMS: AN ALTERNATE SOCIO-TECHNOLOGICAL APPROACH TO NATIONAL EDUCATION AND TRAINING

SCHOOL OF INFORMATION AND COMPUTER SCIENCE
GEORGIA INSTITUTE OF TECHNOLOGY
ATLANTA, GEORGIA 30332

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The Georgia Institute of Technology takes pleasure in bringing to your attention the status and plans of one of its major socio-technological endeavors - the development and evaluation of a comprehensive, new approach to meeting responsibly the increasing demand by society on education.

Your comments and advice are sincerely solicited. We shall especially welcome an opportunity of discussing with you the proposed program directions.

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A PERCEPTION OF NEED

In its continuing effort to respond to some of the major challenges faced by the society of man, the Georgia Institute of Technology embarked, several years ago, on a program of research and development whose primary objective and contribution is an evaluation of an alternate socio-technological approach to education and training in the nation and the world.

The justification for considering an alternate educational system has social, economic and pedagogical roots. Learning, as the acquisition of reason, skill and attitude, is among the most worthwhile activities of man. It has become to be viewed as a lifelong activity and necessity, in part because of the increasing rate of obsolescence of man's technical knowledge, and in part because of the increasing availability (at least in technologically advanced societies) of free time in which adult members of society can pursue individual, socially or materially productive goals. The cost of this added social demand on learning cannot be fully borne from the existing budgets of present-day educational institutions whose financial position is already critical. At the same time it is equally unrealistic to expect that a substantial increase in the financial support of education can be made to meet this demand: the proportion of national resources allotted to education is already very high, and attempts to increase it may unwittingly force the nation to diminish or relinquish its high aspirations for learning.

The consequence is thus clear: education must meet the new challenging demands by improving significantly the cost effectiveness of the instruction/learning process.

A recognition of this consequence has been implicit in many of the attempts in the past decade to apply management science and technology to the process and system of education. It is not inaccurate to conclude, however, that up to the present time these attempts have not significantly increased the cost effectiveness of the social system of education. They did,

however, contribute to the identification of crucial factors bearing on this objective. Some of these factors are perhaps of a temporary nature, such as the lack of organization in the sharing of learning materials and processes, or the high cost of information transmitting devices and communications. Of greater concern are the pedagogic limitations entailed in recent technology-based approaches to educational innovation, limitations which severely affect the effectiveness of these approaches and thus curtail their utility and acceptance.

Objective study and evaluation of technology-motivated approaches to the improvement of educational processes and systems have led the Georgia Institute of Technology to formulate, over the past two years, a major commitment of national significance. The technical objective of this activity is the design and empirical evaluation of an "educational utility" as a mechanism for the delivery of a non-trivial portion of the national requirements for education and training. In pursuing this objective we have, so far, postulated several key functional requirements of future learning systems; developed the concept of a self-instruction system which incorporates these requirements; and implemented and tested operationally a pilot facility representative of the self-instruction system. Our work, summarized below, demonstrates the feasibility of implementing an educational utility for the delivery to society, at the places and times of need, of both learning materials and the pedagogic guidance for their effective assimilation.

THE SELF-INSTRUCTION SYSTEM "ALF"

The concept of a self-instruction system, principally characterized by the absence of the live instructor as the primary and formal transmitter of knowledge, is shown schematically in Figure 1. The major components of this system are an inanimate, structured Memory for storing learning materials in a form suitable for transmission and for perception by remotely located Learners, and a programmed Preceptor controlling the transmission.

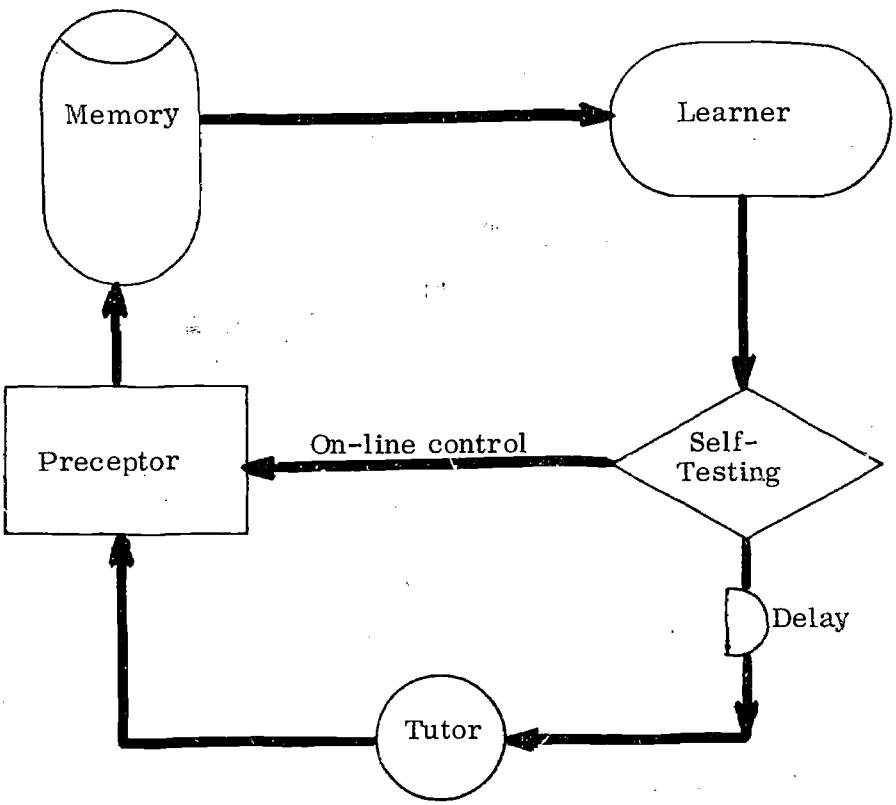

Fig. 1. The Self-Instruction System

Memory contains learning units of variable length, stored in a form suitable for perception by Learner through his aural and visual senses. The minimum necessary content of Memory includes synchronized narrative speech and kinetic graphics--the primary information contained in a blackboard lecture. Each "audiographic" learning unit is identified with respect to its objective (learning goal or goals); and, for each goal, it is linked to its preceding, prerequisite unit or units. Thus for any given learning goal the optimal, the shortest, and the alternate "lists" of learning units can be specified. Additional description of learning units by subject permits the identification, via an index, of subject-related presentations.

The control over the process of self-instruction is partially vested in the programmed Preceptor, and in part it resides with the Learner. Preceptor is programmed to transmit learning materials from Memory to remote locations such as classrooms and other types of conveniently located learning sites. Presentations of learning units normally follow a programmed sequence; the latter can, however, be altered by commands from Learner.

User-imposed control over the system is of two types. On-line control gives Learner the ability to start, stop and repeat a presentation, and to jump at any time to any other learning unit in the system. Using these commands, Learner can override the selection of learning units offered by Preceptor*, and in such a manner participate, on-line, in the design of his learning strategy. The second control mechanism interposes between Learner and Preceptor the services of a human tutor; it is tantamount to an appointment or a conference with a teacher prior to overriding the programmed Preceptor. Incurred in this type of control will usually be a time delay.

The self-instruction system operates in two modes: scheduled, and on-demand. Scheduled operation is authorized by Preceptor programmed

*In its more advanced form, Preceptor is itself a learning, self-organizing system striving to optimize its functions on the basis of certain categories of feedback/commands received from Learners. Among its other functions are monitoring Learner performance, and collecting appropriate data useful for the management of the system.

to release a predetermined schedule of presentations, each running for a specified period of time to specific learning sites, and at specific times. In the on-demand mode, Preceptor receives and responds to requests for transmission of random learning units or unit sequences issued from open-schedule learning sites such as homes, designated study areas, classrooms, etc. Both modes of self-instruction (scheduled and on-demand) can serve, optionally, either group audiences (e.g., a class) or individual learners.

A Pilot Facility for Self-Instruction

To evaluate the feasibility of realizing a self-instruction system of the kind described above, the School of Information and Computer Science, Georgia Institute of Technology, began two years ago developing a pilot learning system called the Audiographic Learning Facility. The main objectives of the effort have been the following:

1. To define the minimum semiotic content of Memory necessary for adequate self-instruction;
2. To develop a model of the self-instruction process, and describe its pedagogic requirements;
3. To define a unit of learning materials suitable for self-instruction, and to specify its content elements;
4. To define the data elements required by Preceptor for the purpose of designing and effecting variable learning strategies under program or Learner control;
5. To store in Memory a small subset of knowledge for experimental self-instruction;
6. To design a physical facility permitting to demonstrate self-instruction by group and individual Learners;
7. To obtain gross initial indicators of the self-instruction system behavior, economics, and effect on human learners and teachers.

The first six objectives have been accomplished, and a preliminary operational evaluation of the Audiographic Learning Facility is currently underway.

The basic distinction of this pilot self-instruction system from other mechanized learning systems is in its storage of narrative-speech and line graphic "blackboard" lessons as the modular contents of Memory, and in actively involving Learners in the design of their learning strategies. The communication between Preceptor and Learner, and the transmission of audiographic learning materials employ standard telephone lines. The implemented hardware system of the Audiographic Learning Facility has a capacity of approximately 120 hours of audiographic lectures, and it supports four remote, on-line learning sites. A limited version of the Preceptor software has been written.

Intermediate Conclusions

The Audiographic Learning Facility attests to the feasibility of the concept of self-instruction systems. In particular it is indicative of the following:

1. The learning materials stored in audiographic form constitute a significant improvement over average live classroom instruction with respect to the following qualitative factors: organization of the subject materials, clarity of presentation, and economy of time;
2. Devices and descriptors can be devised which cumulatively comprise a dynamic, relational index to the logical and pedagogic structure and use of large bodies of substantive knowledge stored in the system;
3. Devices can be devised and included in Memory of the system to facilitate learning diagnoses and self-testing by Learner;
4. The joint use of these devices and the Preceptor's record of the structure of the stored knowledge enables Learner to formulate and revise, on-line, efficient and effective learning strategies, and thus to compensate for the absence of a human teacher in self-instruction.

5. The development of the Memory contents is highly economical in comparison with other media of instruction, both live (classroom teaching) and recorded (television, programmed and computer-assisted learning); the preparation of a 60-minute audiographic lecture - comprising the organization and recording of materials - requires approximately five man-hours of effort.
6. Initial reactions to the self-instruction system by students and faculty are not discouraging.

TOWARD A NEW SYSTEM OF EDUCATION

The evidence of technological feasibility of powerful self-instruction facilities suggests and invites an exciting developmental program. We offer here our perception of a modified social system of education, fully recognizing that it shall co-exist with other forms of learning and education.

The foundation of this system of education is a responsible relationship of two parties sharing a social contract: Learners and Tutors. Participating in this contractual relationship is a third party designated Vendor. The designation Learner comprises all individuals whose common denominator is an objective to acquire intellectual abilities and knowledge, manipulative skills, or affective properties. Tutor refers to individuals or organizations engaged in the performance of a profession whose principal objective is to direct and guide the process of human learning. The principal functions of Tutor consist in designing learning programs; directing, mentoring and monitoring learning processes; and certifying attainment of learning goals. Largely absent from his functions is that of formal delivery of live lectures. Vendor refers to a service agency engaged in the collection, organization and vending of learning materials. Combining functions analogous to those of the publishing and bookselling sector, the computer time-sharing service, and the mass communication industry, this agency procures learning materials from highly reputable educator/scholars, designs and maintains learning systems comprised of repositories of learning materials and procedures for their flexible use, and supports the educators by analytically monitoring the learning processes of client-learners.

The principal modus operandi of the postulated system is suggested in Figure 2. An individual Learner enters into a contractual relationship with an institutional or private Tutor, the nature and costs of which depend on the Learner's objectives and goals; he may wish to obtain a degree, a certificate, assistance in curriculum design, remedial training, advisory

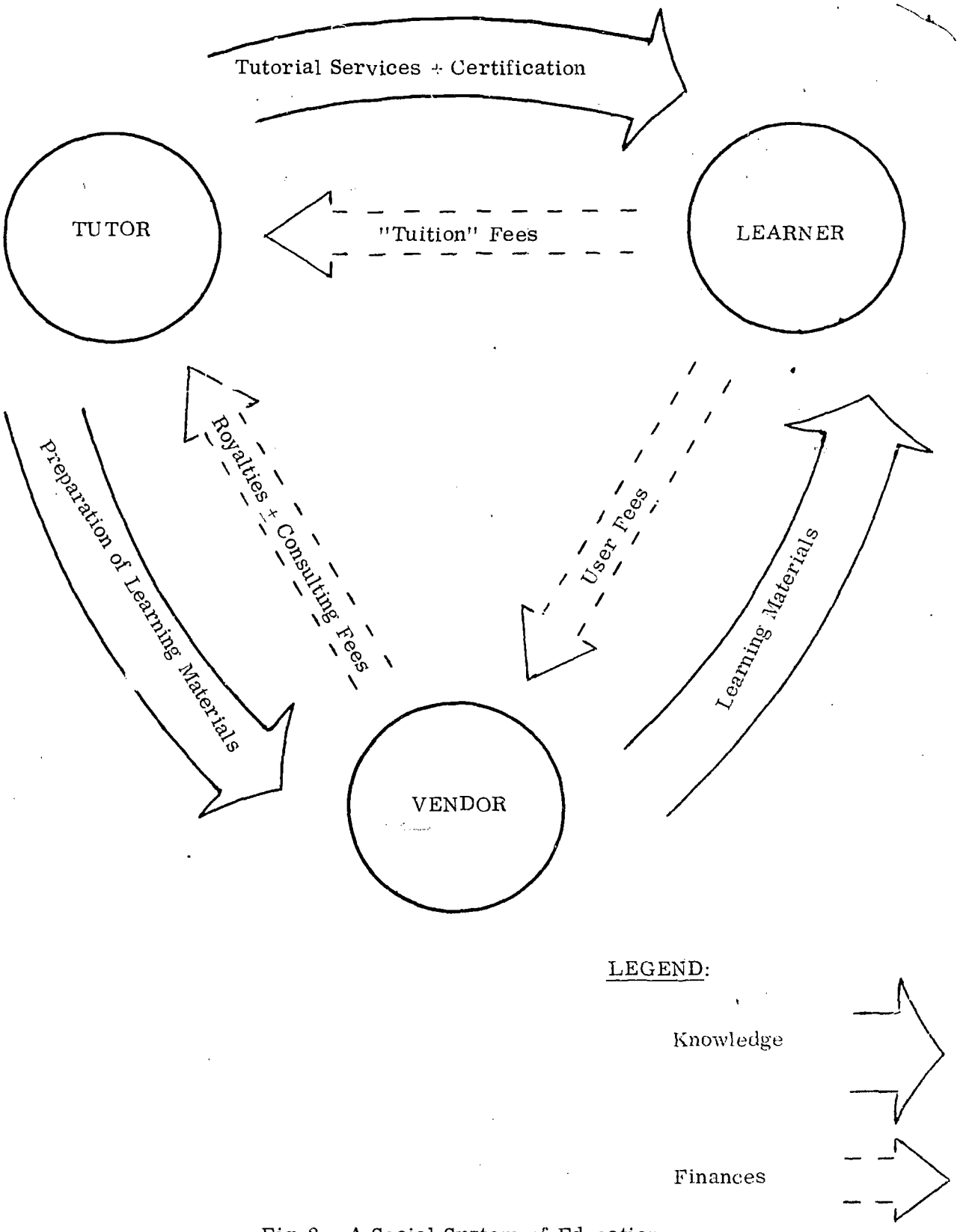

Fig. 2. A Social System of Education

referral service, assistance in the strategy or method of study, clarification or amplification of subject matter, etc. The Tutor develops a suitable course of learning (or suggests a standard program) and a scheduled roster of ancillary events (conferences, discussions, reviews, laboratories, projects, tests, examinations, etc.). Depending on the learning objectives and goals, the principal method of study is a conversational interaction of Learner with learning system provided by Vendor. The latter monitors the learning behavior and performance of Learner for critical evaluation by Tutor.

Learner remunerates Tutor for his professional services according to an agreed-upon cost schedule whose main elements are the type of services rendered (e.g., curriculum design, skill evaluation degree certification, etc.) and the duration of contact. Services of Vendor are covered by a fee chargeable to Learner and varying principally with the duration of his connect-time (and therefore his rate of learning) and the facility used. From his income, Vendor creates, maintains, modifies, updates and extends the store of substantive knowledge; thus part of his income is diverted to Tutor in the form of royalties and consulting fees. Apart from these added financial benefits which he enjoys, Tutor is able to offer Learner a very extensive, flexible and continuously available store of learning materials and procedures.

The social system of education implicit in Figure 2 raises, of course, a very large number of socio-economic and technological issues. It alters drastically the functions of the present-day teaching profession; it affects the political structure of institutions of formal learning; it makes obsolete the time division into academic semesters or quarters, and the division of subject matter into packages of uniform time duration; it permits one person to learn the same body of knowledge or set of skills considerably faster - and considerably cheaper - than another person; it invalidates many of the criteria in which the quality of educational institutions has traditionally been assessed; and so on. Undoubtedly, the effectiveness of the postulated educational system depends critically on finding a proper balance for the functions and rewards of the three principal parties.

PRESENT DIRECTIONS AND PLANS

It is our considerate judgment that the design, implementation and evaluation of a large learning system for self-instruction, based on the ALF concept and principles, is a prudent objective of a broad program of research and development.

Our concept of such a program is that of a large-scale social experiment investigating empirically the feasibility, effectiveness, economics, and social consequences of an alternate, new approach to meeting educational needs of various strata of society and the nation. The major technical elements of the program which we presently desire to undertake at the Georgia Institute of Technology are the following:

1. Selection of the educational environment for the experiment, and of the areas of knowledge or skills for learning;
2. Development of the experimental design for an empirical evaluation of learning by self-instruction, and of the educational system and its effects;
3. Analysis, design and implementation of the physical system; and development of a fully structured memory of learning materials;
4. Operation of the self-instructional education utility in a controlled environment; data collection;
5. Analyses and evaluation of system effectiveness, economics and social implications.

The benefits which such a program of research and development promises to yield are too many to enumerate. Many parameters bearing on the evaluation of educational systems are socio-economic and could not be studied empirically before: the change in functions and activities of educators, the economic effects of shared instruction, or the proprietary of knowledge.

The empirical derivation of individual learning strategies should offer, in the operation of the proposed system, answers to some of the persistent questions about the human learning process, and about the effectiveness of various learning methods. Important, empirically derived conclusions would be inferred with respect to the national system of education. It is our belief that the program of research and development we plan will provide the first empirical opportunity to observe and evaluate the immense social impact of technology on education, and yield information for guiding prudentially the further development of education in the nation.

At this point in time, our important decision involves the identification and selection of one of the many possible educational environments, in which the proposed self-instruction system can be profitably applied and evaluated.

We can conceive of such a system in the environment of formal, degree study, either in residence or off campus. It can be implemented at any of the following levels: graduate, undergraduate, junior college, or high school. Thus a possibility is indicated of a cooperative program with one or more junior colleges in the region in a discipline such as mathematics, computer science and other.

We can equally conceive of implementing an educational system of the type described in the environment of informal education and training, at any one of the following levels: continuing education; adult education; basic adult education; technical, vocational and industrial training. The appropriate milieu for implementing the proposed program might be a community learning center, or a university department of continuing education, or even the framework of a "free university".

Yet another profoundly meaningful environment in which such a program should be contemplated is the education and training of disadvantaged and handicapped. We have designed a kinesthetic/graphic terminal device for the Audiographic Learning Facility which permits a blind person to perceive line graphics, patterns, etc. kinesthetically, making it possible for such a person to participate in the instruction process simultaneously with sighted persons. The same device appears of much interest in the teaching of writing to sighted children

and adults. Any one of these applications of audiographic self-instruction systems is highly justifiable. The selection of subject matter is flexible to accomplish a broad range of learning objectives: cognitive (e.g., applied mathematics, anatomy), psychomotor (e.g., writing, drawing), and affective (e.g., human relations, civics).

Clearly, the selection of an educational or training environment and a subject field is most important, and should be guided by social, political as well as economic considerations. For these reasons, we are soliciting and inviting suggestions and recommendations from various knowledgeable groups and individuals, in educational and professional organizations, foundations, and in government. Our concern is that the commitment of human and financial resources to the program we contemplate must have a guarantee of highest social benefit.