

A COMPUTER-BASED LANGUAGE INSTRUCTION SYSTEM

WITH INITIAL APPLICATION TO ARMENIAN

by

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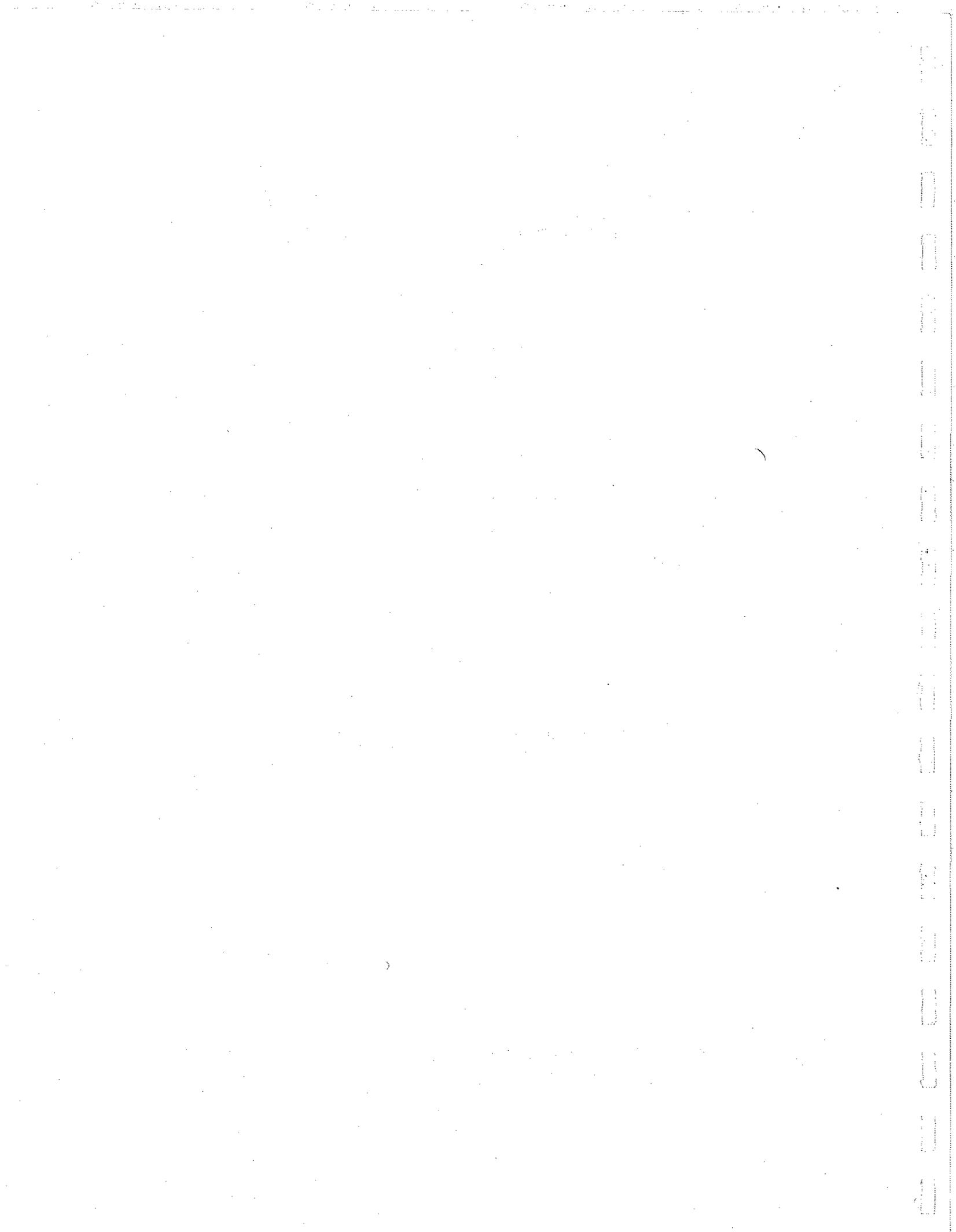
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### Abstract

This paper describes the development of a language instruction system for the esoteric languages in which the computer is the primary medium of instruction. The initial application is to Armenian. Instruction under the system takes place at a computer terminal with a video-display screen which serves both as a blackboard and as a worksheet for the student. Each terminal is equipped with an audio amplifier and headset, through which the student receives aural instruction. English and Armenian sentences that the student hears are synthesized by the computer from previously-recorded and LPC-encoded speech. This paper discusses linguistic, pedagogical and technological aspects of the language instruction system. Some social conditions which favor the use of the computer for teaching Armenian are reviewed.

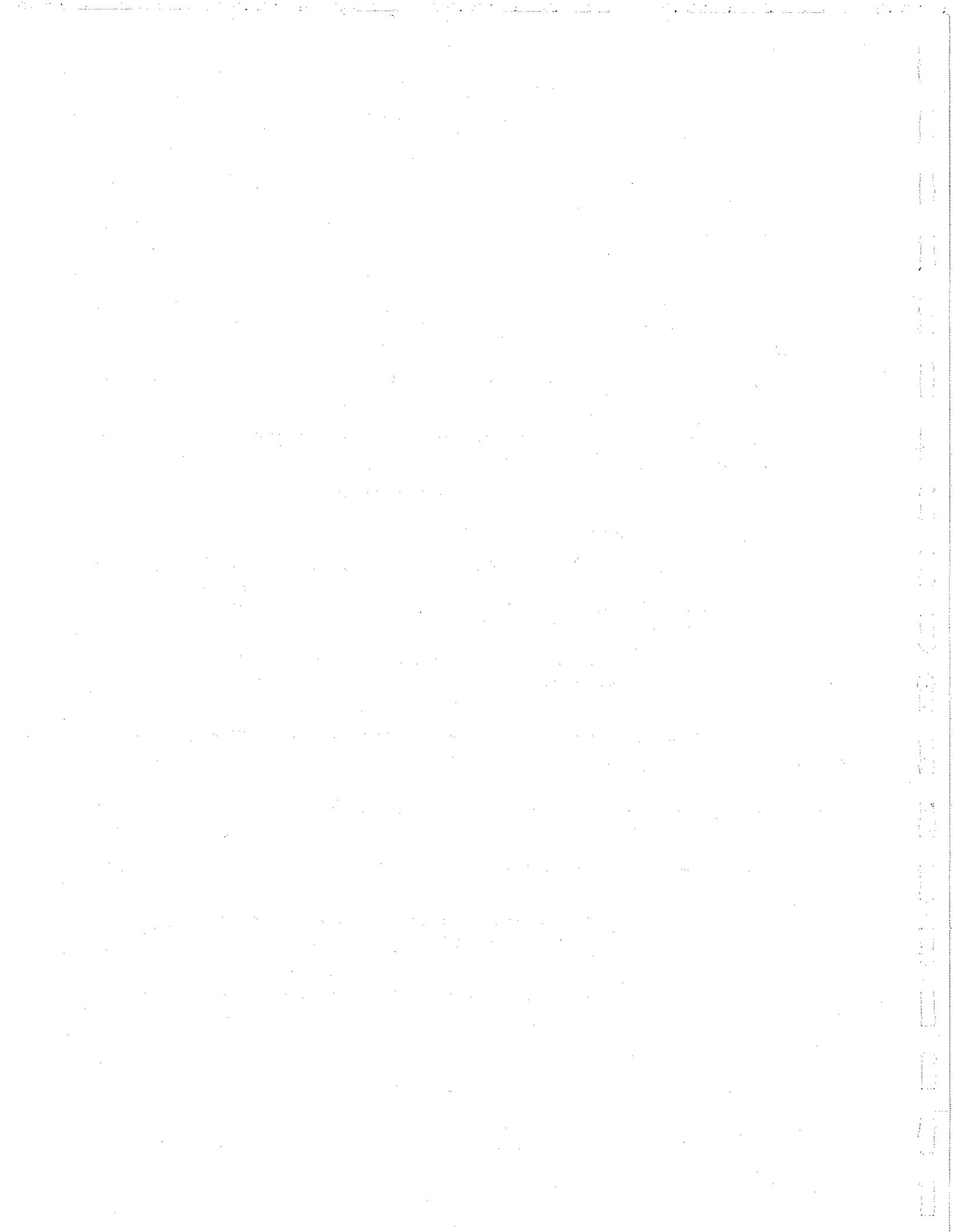
### Acknowledgements

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In my heart I drank to the health of young Armenia  
... and to its mighty language which we are unworthy  
of speaking, but can only avoid in our febleness.

Osip Mandelstam, Journey to Armenia

RECORDED

## 1 Introduction and history

The current Stanford University computer-based instruction systems were developed specifically for mathematics-oriented subjects such as logic and set theory [9], [43], [44], [45], [46].

As a part of its current research program, the Institute is applying current CBI technology to instruction in foreign languages, especially the uncommonly-taught languages, including, initially, Armenian. Extensive research over the past decade at the Institute has demonstrated the efficacy and efficiency of using computers for language instruction [4], [5], [22], [26], [41], [47], [48], [49]. Present work on computer-based language instruction employs current technology such as computer-synthesized speech; in addition the underlying linguistic and pedagogical framework of the Stanford CBI system is being extended and adapted to language instruction.

A goal of our current work is to develop a set of computer-based courses for Armenian at various post-secondary levels and to make these courses available to educational institutions on a nationwide basis, using one of several existing or developing distribution methods. Since the Stanford computer-based language courses are being designed to be taught largely or entirely by the computer, they will make language instruction possible even where there are no qualified instructors, or where it is economically unfeasible to hire one.

## 2 What is a computer-based course like?

Use of the computer as an instructional aid is not a new idea. Over the years many instructional packages of programs have become available, especially for use by students of mathematics and physical and social sciences [17].

Only relatively recently, however, have researchers begun to explore the potential of the computer as the primary medium of instruction, a role in which the computer assumes many of the tasks which were formerly the province of graders, teaching assistants, lecturers, and even seminar leaders. To focus on the central role of the computer, we distinguish computer-based instruction (CBI) from computer-assisted instruction (CAI) and computer-managed instruction (CMI).

In a computer-based class there is no classroom in the traditional sense. Instead, there are rooms equipped with video-display terminals; these terminals are connected to a main computer (located in another building). Attached to each terminal is a headset, which is also connected to the computer. Through these terminals students have essentially 24-hour access to the computer, six days a week.

A student in Stanford's Armenian course begins his language

lesson by typing his name and student identification number at a vacant terminal. The computer remembers pertinent information about the student, including where in the course he was when he last finished. The computer thus knows at what point in the curriculum the student is to begin.

The computer begins the day's work by presenting expository material to the student through two information "channels": a visual channel, by printing or drawing on the video-display terminal; and an audio channel, by speaking to the student directly through his individual headset. For example, the day's work might begin with instructions by the computer on Armenian greetings. The computer might print examples of greetings in Armenian on the display screen, and at the same time speak the Armenian greetings to the student. English translations might also appear alongside the Armenian. Through a variety of techniques, the student can control the rate at which the lesson is conducted; he can interrupt the planned sequence in order to obtain repetition or clarification of information.

Following this presentation, the program may drill the student on his mastery of Armenian greetings. He may be required to reformulate a greeting in a variety of contexts. The student's responses are typed at the keyboard and appear on his screen as they are typed. At each point the computer can provide immediate evaluation of the student's response, and immediately inform the student of the adequacy of his performance.

The student may work at the terminal as long as he wishes. In the Stanford CBI logic course, some students finish all the required material in the first few weeks of the quarter; most take the full ten weeks to complete the computer-based curriculum. There is no examination or test in the logic course; grade attainment is a function solely of material completed. If necessary, continuous evaluation of the student's performance can be made.

### 3 Computer-based instruction as a tool for teaching foreign languages

In developing a computer-based instruction system for Armenian, a foreign language not commonly taught in the United States, we are actually addressing a more general issue of foreign language instruction. Most American universities and colleges offer regular courses in the most important and popular languages. At Stanford the five most popular languages account for an estimated 95 per cent of enrollment in introductory language classes. Beyond these, the majority of the world's languages either are not offered at all or are offered through language labs, on tape, or through tutors on an as-available basis. At Stanford, tutoring is the system used by the Special Language Program of the Department of Linguistics to offer the uncommonly-taught languages. These tutors, however, often are not trained language teachers, and cannot offer instruction on as sophisticated a level as is found in the regularly-offered languages.

The computer-based Armenian course is being offered in the Special Language Program during the current academic year. The computer serves as a well-trained instructor and is assisted by a tutor who is a native speaker of Armenian. The tutor's function is to check the student's pronunciation and to engage in natural and informal conversation in the language learned.

### 3.1 Automatic drill generation and repetition

The computer is a tireless instructor that can carry out the repetitive drills of language instruction indefinitely. Since drill and practice are the keys to adult language learning, the importance of a well-programmed monitor in this repetition can hardly be overemphasized. However, even in a relatively small language class of, for example, eight students, the maximum average "solo" overt response time per student during a 50-minute session cannot be more than 6-1/4 minutes. In practice, it is much less than that. During a computer-based session of equal length the student is responding overtly during a much larger period. In the Stanford Russian CBI course, students made up to 200 or more teletype responses to as many different stimuli in a single session [47]. While the average classroom overt-response time can be increased by such group activities as taking dictation, the correction of responses by the teacher in these activities takes place, if at all, only after an entire set of sentences has been written and handed in by the student.

With computer-generated drills, on the other hand, student responses are evaluated and corrected immediately. Furthermore, drills are generated in a semi-random fashion from vocabulary already known to the student. (see Figure 1). Moreover, the drills are not translations of English phrases but are generated from the syntactic and semantic categories of Armenian. (for an example, see Appendix C).

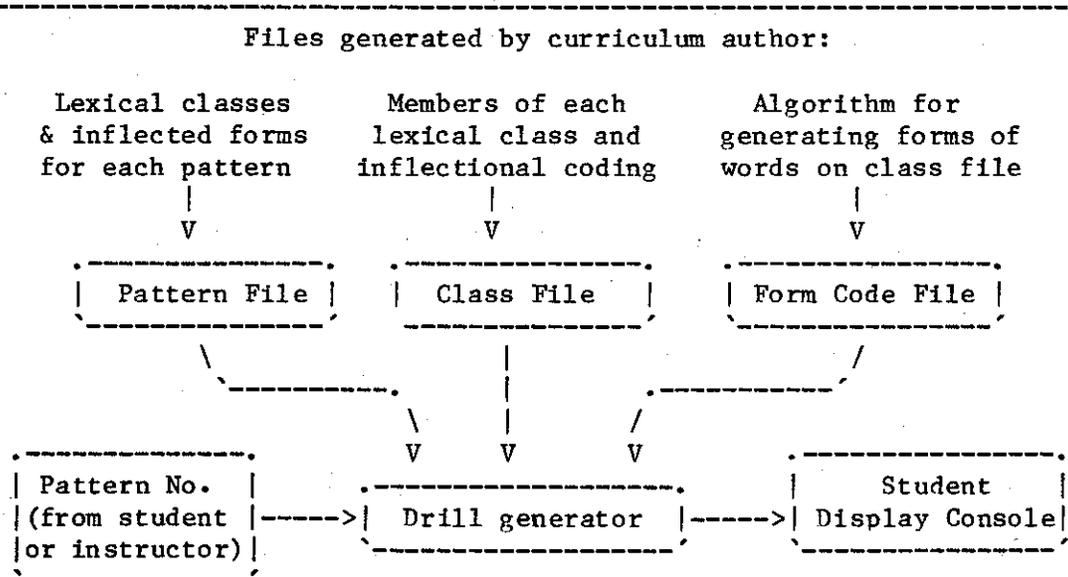


Fig. 1: Generation of pattern drills

### 3.2 Individualized instruction

The computer also brings a high degree of individualization to language learning. (For a general discussion of individualization in the computer learning environment, see [13].) Here we discuss the most important aspects of individualized language instruction provided by the computer.

1) Self-pacing: The fact that a student is by himself at the terminal, as contrasted with being a member of a group, makes for a very desirable learning environment: the student can proceed at a rate that is comfortable and most conducive to learning for him. Thus, he can take the time he needs without either hurrying others or wasting their time.

2) Repetition of any material at will: A feature of the Stanford computer-based instruction system is the choice at very frequent opportunities either to repeat what went before or to proceed to new material. This again is a very desirable feature in language instruction, where one student may be able to imitate new material with one exposure, whereas another might need five repetitions before managing it himself.

3) Freedom from assigned hour: The fact that the computer is available essentially 24 hours per day, 6 days a week, is another aspect increased individualization. Individual students each have "best learning times" which vary considerably from person to person.

4) Student does not hear mistakes of others: Unlike a regular classroom session, a computer-based language session is free from false starts and distracting inquiries being made by other students. Most importantly, however, the student hears only two voices: his own and that of a native speaker. The elimination of the mispronunciations of other students is thought to have contributed to superior pronunciation observed among students in the computer-based Russian course [47].

In the comparison of student performance made between the computer-based and lecture-style introductory Russian courses in 1967-68 [47], it was found that students in the computer-based class not only demonstrated superior performance but also had a sharply lower attrition rate. Thus, only 40 per cent of the students in the regular course completed the second quarter, whereas in the computer group 80 percent finished the course.

5) Individual strategies of learning: Learners differ in a number of ways in the strategies they use for learning. In language learning, specifically, several strategies can be identified: some students seem to want to listen for a long time before they venture to say anything themselves in the new language. The computer allows for this strategy automatically, while in a regular classroom it would be difficult to have special or preferential treatment for a few students. On the other hand, the student who likes to "jump in", is unafraid of making mistakes, and learns by trial and error, can do so easily also without embarrassment or self-consciousness.

6) Interactive instruction with immediate feedback on errors: Perhaps the most important factor in the individualization of learning through the computer is that it is interactive. By this we mean that the student is not just passively receiving information but is being called upon to perform some task (repeat, type, copy, form a sentence, substitute words in a pattern, etc.) much more frequently than in a traditional classroom. Furthermore, on every task performed, the student is told immediately whether he is right or wrong and, if wrong, what his mistake is and what the correct answer is.

### 3.3 Checking pronunciation

The principal drawback of computer-based language instruction is that the computer cannot evaluate oral input - it cannot hear. The student thus has no feedback from the computer on his pronunciation in the new language and must avail himself of a speaker of Armenian to perform the evaluation. At Stanford, the speaker is a tutor who checks the student's progress in both pronunciation and other aspects of the language. At other institutions, where there is no assigned tutor, the student will be advised to "practice" his limited Armenian with any Armenian-speaking friend or relative. On the other hand, if the computer program is used in an established language course, the teacher will be able to spend more time with each individual student to work on that student's particular pronunciation difficulties, rather than on standard classroom drill and practice.

### 3.4 Acquisition vs. learning

A distinction made in foreign language teaching [27] is between second-language acquisition and second-language learning. Acquisition refers to the unconscious internalization of the second language with focus on communication. Learning refers to the conscious, well-monitored

training in the rules and generalizations of the second language. The computer-based program we have been describing offers ample opportunity to learn but very little language environment for acquisition.

Although conversational dialogues have been included in the programmed curriculum, there is no communicative interaction between student and computer the way there could be between two human beings concentrating on the message rather than the form. This is again where the role of a speaker of the language becomes important for the student; a well-trained teacher can be crucial. When relieved of the more repetitive and monotonous tasks of language teaching, the teacher is free to devote more time on creating an acquisition environment where the student is exposed to varieties of situations where he can use the new language, within his ability, to communicate in a natural manner.

Let us consider the contrast between a student with years of formal learning with no fluency in the language and a student who has spent a few months in the country where the language is spoken. This contrast suggests the role being defined for the foreign language instructor: he is to complete the foreign language learning environment with natural, conversational interaction about real life situations where the focus is the message, the meaning, and not the form or the structure.

#### 4 Social considerations in Computer-based instruction of Armenian

The Stanford University Armenian Language Project was originally conceived during discussions in the summer of 1977 at Stanford on the state of Armenian language instruction. Drs. Joseph van Campen, Zaven Guiragossian, Hasmig Seropian and Patrick Suppes, together with Lawrence Markosian and other Institute researchers, agreed that computer-based instruction is particularly well-suited to teaching Armenian, for both social and linguistic reasons.

The American-Armenian community illustrates many of the social and economic problems involved in teaching specialized language courses.

The Armenian community in America, estimated at about 3/4 million, is widely dispersed, with only a few concentrations in such cities as Fresno, Los Angeles, Detroit, Boston and New York. In fact, a similar dispersion of the Armenian population holds on a worldwide basis, with most Armenians residing not in the Soviet Armenian Republic but in other countries of the world.

On the other hand, there is widespread support in this community for formal instruction in the language, especially among third generation Americans of Armenian descent.

For example, in recent years thirteen Armenian elementary and secondary schools have been founded in cities having a significant

Armenian population; all these schools provide instruction in the language. However, these schools can serve only a small portion of the community. In addition, even in the Los Angeles area, which has a large population of recent immigrants from the Near East, there is a shortage of qualified language instructors.

Again, because of the dispersal of Armenian-American students among a large number of institutions, only a few colleges have sufficiently large demand to offer courses in the language. Additional programs of college-level language instruction are supported by endowments from Armenian individuals and foundations; without these endowments the programs might not be preserved.

Finally, the quality of language instruction available to non-traditional students is generally poor. Frequently the language is taught in Armenian community centers by members of the community who are not trained in language instruction.

It is clear that these few schools and post-secondary programs will be able to serve only a small percentage of students in the dispersed community; the overwhelming majority of Armenian-American students have and will continue to enroll in a wide range of post-secondary institutions, generally without a large enough number at any one site to justify offering a program of courses in the language. At Stanford, for example, the Armenian language had never been offered prior to the initiation of the computer-based instruction project. On the other hand, it is thought that a considerable interest in the language does exist on the campus.

The preservation of specialized post-secondary level language courses such as Armenian, which can be expected to have only limited enrollment within any one institution, can be done effectively and economically by the use of modern educational technology.

## 5 Linguistic considerations in an Instructional Program of Armenian

One of the initial selections made in developing curriculum material was between the Eastern and Western dialects of Armenian. Western Armenian was selected for the first course, with the intention that once the program is completed, the language content may be modified to teach Eastern Armenian in addition. It is perhaps worth mentioning that there is no system or program constraint on the dialect; curricula can be developed for either dialect.

Another question was the level of the course. For the first course, we decided on a first-year college-level course to be offered initially at Stanford. Such a course could easily be adjusted for any adult group of students and for high school students.

The more pressing matter both at the start of the project and

throughout its course has been to analyze and organize the language content itself to meet several objectives:

A. The first of these objectives was to make the language content interesting and relevant to the student's life. Certain problems have continually plagued Armenian language instruction in this country: an apathetic environment for language learning; curriculum materials centered on subjects remote from the student's everyday life; and too-literal translations of English sentences into Armenian.

By contrast, the goal of the computer-based lessons has been to select and present material of immediate applicability to the student's day to day life. Sentences that speakers of Armenian never use have been avoided. On the other hand, sentences which students can use with family and friends have been included as early as possible.

B. The second objective was to organize the language content not only to progress from simple to complex but also to maximize the amount of drill and practice for those aspects of Armenian which speakers of English find most difficult. In this organization, care has been taken to introduce new material one item at a time, drill it for initial learning, go back to it soon and drill it again, and make it part of later lessons. In other words, nothing is left hanging as an isolated item to be memorized and then forgotten a week later. This intricate weaving of the material is done both for the vocabulary and for the sentence patterns.. (see the example in Appendix C).

C. The third objective concerns teaching Armenian writing. As described in Section 7, the computer terminals are programmed to display Armenian and the lineprinter is programmed to print it. Students see on the screen whatever they hear on their headphones. Moreover, they have an Armenian keyboard on which they type their answers. Thus they learn to write whatever they learn to say. In addition, they are given handouts which teach the strokes of the alphabetic letters and review material in printed form.

Thus, the curriculum teaches spoken and written Armenian simultaneously. The fact that spoken Armenian is taught is not intended to minimize the importance of reading and writing. However, as we work from the observation of linguistics that the primary life of a language is in its spoken form, we do believe that even for someone who is only interested in reading and writing Armenian (and not speaking it), learning the spoken language greatly facilitates the learning of reading and writing.

D. The fourth objective is that of teaching the grammar of the language. Because of the ambiguity of the word 'grammar', we would like to point out that in saying we teach the grammar of Armenian, we do not mean that we teach lists of declensional and conjugational paradigms. What we do mean is that we teach the syntactic patterns of Armenian as they are used to express the varieties of meaning in the use of a language. In this, again, our work is based on theories of modern linguistics, especially the research of the last two decades when the

focus of linguistic inquiry shifted from words and lists to syntactic structures and the concepts they express [14], [15], [16], [20].

E. There are some other questions of language teaching methodology that we would like to mention here with our approaches to them.

Confronted with conflicting theories of language acquisition and different methods of language instruction, our approach in developing the Armenian Instructional Program has been an eclectic one. With the objective of teaching Western Armenian to speakers of American English, we have relied on contrastive analyses of the two languages, but, more importantly, we have tried to order the language content with the complexities of Armenian in mind.

With no data on the order of acquisition of Armenian either as a first language or as a second language, our work has had to judge the language from within. We have drawn on the literature of language acquisition in other languages wherever relevant. We have also relied, wherever possible, on the accumulated experience in teaching English as a Second Language, which has the most extensive research on methodology. Translation is never used as a learning exercise and it is kept to the minimum of giving the meaning of a word or a sentence when first introduced.

## 6 Development of a CBI system for Armenian

The issues raised above were concerned with the content of our language course and addressed matters apart from the computer. The form of our lessons, on the other hand, is adjusted to the computer and should be discussed by itself.

A computer-based lesson bears little resemblance to a textbook or classroom lesson. In comparing it with a classroom lesson, we can draw the following parallels: what the student hears through headphones is like an instructor talking to the student. On the other hand, the upper two-thirds of the screen the student is looking at is like a blackboard where the teacher is writing new material. There is, however, a crucial difference from a classroom blackboard: material can be written and erased on the screen much faster than it could ever be done in the classroom. Furthermore, while writing on the blackboard requires time and energy and space in a book is very costly, blank space on the screen does not cost anything and writing on the screen is very easy.

The remaining lower one-third of the screen below the blackboard is called the scroll region: a place where the student sees his answers, can compare them with what is in the "blackboard", correct himself, and finally enter the answer for evaluation and see the evaluation.

The computer-based lessons are written in the VOCAL curriculum author language (discussed in the following section) and are not easily compared with textbook-style lessons.

In the preparation of instructional material for the computer, one of the curriculum author's tasks is to incorporate into the program every detail of the language as an individual item. The author must anticipate the most common questions a student might ask and mistakes he might make. This task, combined with the already-discussed task of ordering the language content itself for best learning, forms the bulk of curriculum preparation we have done for the first-year Armenian course.

## 7 Recent developments in CBI technology

The original computer system used for Russian. The computer-based Russian course described above was developed for use on the PDP-1 computer then in operation at IMSSS. The programs were developed specifically for the Russian course and were limited by the ZEUS operating system then in use, and by the PDP-1 hardware capabilities. For example, the PDP-1 then allowed each user 12 K of core (where 1 K is 1,024 18-bit words). The primary output devices were Model 35 Teletypes and tape recorders. These programs were later adapted to run on the PDP-10.

Current computer environment at Stanford. Since that time there has been a vast improvement in both the hardware and system software available for interactive use, especially for CBI. The modern IMSSS PDP-10 (a dual-processor model KI-10) operates under the TENEX timesharing system, a virtual memory paging system which allows the user 256 K of memory (where 1 word is 36 bits, twice the size of the PDP-1 word). The actual hardware memory has been increased to 512 K. Disk space is 140,000 pages. Many features have been added to the system software to facilitate its use for CBI. The existence of such a system designed for highly interactive use has allowed development of a sophisticated CBI technology.

Author language for video display terminals with audio. One such development has been the Voice-Oriented Curriculum Author Language (VOCAL) [24], which is currently used to write curricula for Stanford's mathematics-oriented undergraduate-level courses (logic, set theory, proof theory and probability theory) and language courses. VOCAL is designed to allow an author with no previous instruction or experience in programming or computer science to write CBI lessons. The language permits precise coordination of audio and video display material with student responses. An extensive answer-analysis machinery is available to permit highly individualized program responses. (For a discussion of the VOCAL language, see [28].) The goal is to provide an informal, lecture-style presentation with far greater individualization of instruction than possible in a lecture class.

A sample Armenian exercise written in the VOCAL language is included in Appendix B.

Displaying and printing Armenian: The computer-based Armenian curricula and programs are being prepared and tested on the Institute's IMLAC video-display terminals<sup>1</sup>, which allow software-generated character sets. The IMSSS text-editor is being extended to allow use of the 38-letter Armenian alphabet [25]. Guiragossian, Kannerva, R. Maksudian and Markosian have already designed and programmed the Armenian character set for use on the IMLAC video-display terminal and the Institute's Printronix lineprinter. (The sections of this paper in Armenian were printed using these systems.)

Other CBI developments. Other recent CBI developments at Stanford include computer-synthesized speech generation (discussed in Section 8); interactive proof checkers and theorem provers for use in the CBI environment [9], [10], [35]; parsers and grammars for formal and informal mathematics [44] and for natural languages; systems for displaying, editing and printing text in a variety of alphabets and languages [25]; and student "help" systems and other techniques for individualized instruction. In addition, data-collection facilities have allowed close monitoring of individual students' performance [29].

#### 8 Use of computer-generated speech in college-level CBI courses at Stanford

Tape recordings. The Russian course used a system of pre-recorded audio tapes to present audio material to the student. These tapes allowed only limited program control, and no student control, over audio segments. In particular, the audio handling was not interactive, in that control of audio segments was independent of student responses. Thus, for example, the student could not adjust the audio speed, ask for repeats, skip some messages, or review material at his option. The program, too, was limited to playing the tape-recorded segments in linear sequence. Since each student job required a tape drive with the proper tape mounted, the number of jobs allowed at any given time was limited to five (the number of tape drives available), and a proctor was required to select and mount the appropriate tapes [47].

Computer-synthesized speech. Over the last few years several systems of computer-synthesized speech have been developed at IMSSS [38], [39], [36], [37], [40]. These audio systems are used together with video display terminals to provide an informal, lecture-style presentation. In one system, called "long sounds", audio recordings of

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<sup>1</sup>The IMLAC is a full-graphics terminal which has been in use over a number of years at IMSSS. It is easy to program and its graphics capability enhances its flexibility for development work. However, there are other, commonly-available terminals which can be programmed to display Armenian text.

the spoken material are made; these recordings are processed and stored in a compressed, digitized format on the computer system's random-access disk. The appropriate digitized sentences are then selected by the course program and used to generate audio messages for the student. Up to 48 audio channels are available for student use. Since the entire audio component of a course is recorded and digitized, a large disk storage capacity is required by this system. Current research is expected to result in a significantly smaller storage requirement with only slight degradation in audio quality.

Prosody. A second method of speech generation parses English language text, looks up the basic audio representation of English words in a stored dictionary, and adds the appropriate prosodic features to these audio representations of individual words [31], [32], [30]. Research at IMSSS on prosody systems for English have concentrated on one of several methods. A prosody method requires far less disk storage since only a vocabulary of words used (with their audio encodings) is required, in addition to the original parsed text sources.

Either prosody or long sounds permits random-access to all audio segments.

Speech generation for language instruction. A prosody system is being implemented for all upper-level undergraduate mathematics courses at Stanford, and constitutes a current area of research in computer generation of speech. However, for the language instructional system we are using the method of recording the entire spoken component of the curriculum, since the audio quality of this method is currently superior to that obtained by the current prosody system. In addition, no research has been done on the prosodic features of spoken Armenian.

Suitability of computer-synthesized speech for Armenian. Over the past year, experiments at IMSSS have demonstrated the suitability of the computer-synthesized speech system for Armenian. In particular, the speech system reproduces the many Armenian sounds not found in English. These experiments tested the "long sounds" system of digitizing and synthesizing entire spoken phrases, which is the system we are using for most of the language courses.

## 9 Use of the Stanford instructional system at other sites

Under our current funding we are undertaking to develop a system for computer-based instruction in Armenian which will be used initially at Stanford University. The system will be evaluated over a period of several years with Stanford undergraduates. In addition, under a recent grant from the National Endowment for the Humanities, we will be making the system available on an experimental basis to students at a nearby community college beginning in September of 1980. The community college will be provided with the equipment necessary to allow it to run the programs through direct telephone connections to the Institute's

computer system for the academic year 1980-81. (For a discussion of the remote use of the speech synthesizer via telephone link to the IMSSS computer, see Appendix A.)

In addition, a non-audio version of the part of the program which generates pattern and vocabulary drills has been tested successfully on three computer systems other than the development site. This program, used with a suitable video-display terminal, can provide language drills as a supplement to traditional language classes. The programs can be used on use on the DEC-20 and PDP-10/TENEX computer systems.

The next stage in making the system more widely available is to produce a version of the programs which run on a variety of different computer systems. Part of this work is currently being supported by a grant from the Fund for the Improvement of Post-Secondary Education (FIPSE), a federal agency, to the State University of New York at Binghamton and Stanford University. (A description of this work, together with a more detailed discussion of questions of transportability, can be found in [2] and [3].) Depending on the success of this project, a non-audio version of the basic instructional programs will be available for a suitable IBM system (CMS) within three years.

The FIPSE transportability project will not, however, support the transport of the speech synthesizer, which is of course essential for the Armenian courses currently under development at Stanford; separate funding will be necessary for this task.

The transportability of large computer-based instruction programs is a complex issue with both technological and sociological aspects. The Institute's current work addresses both these aspects within the limited context of the Stanford instructional system. (For a different perspective on questions of production and dissemination of computer-assisted instruction material, see [12].)

The Stanford Armenian Language Project does not address all the questions of transportability (the same questions must be faced by all complex CBI systems, not only the Armenian program). The goal of the Armenian project is to apply state-of-the-art technology and current linguistic and educational research to teaching Armenian; and, using dissemination techniques as they become available, to offer the resulting system to institutions which wish to utilize computer-based instruction.

The timing of the project takes advantage of the increasing availability of the necessary technology through efforts on the part of industry and government. Since Stanford Armenian Project was conceived in the summer of 1977, we have observed continued declines in the cost of computer equipment, and increasing availability of key components. For example, inexpensive speech synthesizers are being marketed by Texas Instruments, and others are on the way. Texas Instruments' "Speak and Spell", an educational computer toy containing rather sophisticated

technology (including a speech synthesizer), retails for about \$60 in department stores.

As Bork points out,

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. [11]

These rapid developments in the computer industry will make possible teaching Armenian and other esoteric languages on a scale never before thought possible.

## Appendix A

### Remote use of the MISS speech synthesizer

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Stanford, California

The MISS machine was designed to provide access for a large group of users to audio, and also to permit easy implementation of future improvements in speech compression. For these reasons, the MISS machine is not well suited for duplication for use with small clusters of remote terminals. However, the Institute is currently funded to develop a MINI-MISS machine which would be suited for such applications and easily duplicated.

Two recent developments make a MINI-MISS machine possible. First is the compression of linear prediction parameters down to less than 3000 bits per second. In fact, Blackman, Viswanathan & Makhoul [8] recently demonstrated a 1600 bps system with a high enough quality for most communications purposes although probably not high enough for language instruction. However, recent Institute experiments have demonstrated the feasibility of 3100 bit per second speech while maintaining very high quality. The second development is the introduction of very high speed bit-slice microprocessors such as the Advance Micro Devices 2903 and high speed multipliers such as the TRW TDC1010J. With a small number of integrated circuits, all the calculations required for two or three speech channels can be performed.

One problem still remains, namely, how to get the speech data to the MINI-MISS machine. Two alternatives present themselves: sending the data over digital phone lines, and providing a small disk at the remote site. A pair of 9600 baud data sets for a phone line presently costs about \$10,000 and can handle two channels of voice data and four channels for terminal display data. The phone line rental costs vary but can be approximated at 6 dollars per mile per year.

A 20 megabyte disk can store about two hours of recorded phrases or a vocabulary of about ten thousand words. This would be adequate for most courses. The recent introduction of Winchester technology disks in the 20 to 30 megabyte range for less than \$3000 has made remote vocabulary storage practical. A pair of lower speed data sets for transmitting the speech commands and display data would be needed and would cost about \$2,000.

Our long-term plans call for implementing remote audio in two stages. The first stage, and the easiest to implement, is simply to

connect an output channel of the present MISS machine to a telephone line and provide an amplifier and earphones at the remote site. Each remote terminal must have its own telephone line with its associated charges. However, this provides complete flexibility in creating and updating the speech data base at the central computer at Stanford.

An alternative to the first stage consists of putting a MINI-MISS machine in a remote site and provide it with speech data over a phone line. The MINI-MISS machine would serve four terminals, although only two could be talking simultaneously. It would handle both terminal data and speech generation. We have rejected this alternative for the language instruction program since the cost of the datasets and the required 9600 baud data line are prohibitive.

The second stage is to provide a MINI-MISS machine with disk to a remote site. The MINI-MISS machine and disk would still be controlled by programs running on IMSSS central computer facilities. However, the audio would be stored and generated at the remote site. This configuration would require only one 2400 baud line plus data sets, at a considerable savings to the user.

## Appendix B

### Sample VOCAL exercise

As noted in in Section 7, the VOCAL language allows a curriculum author to specify in a precise manner the presentation of information on the display and through the audio. In addition, it allows him to control the machine-student interaction. A VOCAL "lesson" thus bears little resemblance to a textbook lesson. We include part of an Armenian exercise written in VOCAL here for illustration only; a detailed explanation of the language can be found in [24].

[Exercise 7 "New Verbs"

[Audio

(Tem

"

	GART-AL	to read	1
	G GART-AM	I read	2
[TERT]	G GART-AM	I read [the] [paper]	3/a,b,c,d
	SORV-IL	to learn	4
	G SORV-IM	I learn	5
[HAYEREN]	G SORVIM	I learn [Armenian].	6/e,f

"

The area within the quotes is a template of the display screen. Not everything in the template appears on the screen at once; instead, the author includes commands to print certain lines or parts of lines at various points as the student progresses through the exercise.

Interspersed with messages printed in the display area, the author may specify certain Armenian and English messages to be spoken through the student's headset. A typical example involving both printing and speaking appears below. The example intermingles printing and speaking and includes pauses to allow the student to repeat aloud what he hears in Armenian:

```

(hold (s
      (language "english" "false" "true")
      "Listen to the verb ""to read""."
      (language "armenian" "" "false")
      "GARTAL"
      ((t 1)(w 1500))
      "GARTAL"
      (w 1500)
      (language "english" "false" "true")
      "Repeat."
      (language "armenian" "" "false")
      "GARTAL"
      (w 2000)
      "GARTAL"
      (w 2000)
      "GARTAL"
      (w 2000)
    )
)

```

In addition, the author has the ability to question the student and evaluate his responses; an example of the VOCAL code appears below. Again, the code allows the intermingling of printed and aural instructions:

```

(q      r4
      init (((language "english" "false" "true")
            (s "Type.")
            (language "armenian" "" "false")
            (s "GARTAL")
            (language "english" "false" "true")))
      a      (ans "GARTAL")
      ca     (s "Good. That's a hard word to spell.")
      wal   (
            (s "Check the word on your screen
              carefully.")
            (s "Try again.")
          )
      fail  ((t "The correct answer is `gartal'.")
    )
)

```

The above examples illustrate the principal capabilities available to the curriculum author. In addition, the author may easily specify language drills to be done by the student at the computer terminal.

Lesson authoring is facilitated by a page-oriented text editor [25], which allows the preparation and revision of lesson material at the computer terminal. The use of the text editor and the VOCAL compiler allow the author to generate, test, and revise the lessons interactively at the computer terminal, and reduce the need for "hardcopy" computer printout.

## Appendix C

### Examples of Armenian Drills

The following are examples of computer-generated pattern drills, together with the student responses, in the form in which they appear on the student's video-display terminal. For each pattern, only a few examples are printed; the program will normally generate many examples of each pattern, limited only by the vocabulary available to the student at the point the drills are presented.

The student responses appear to the right of the asterisks and are indented.

Pattern number \* 34

[Third singular of negated present tense of "to be".]

համով, միս

միսը համով չէ

կծու, մածուկ

\* մածուկը կծու չէ

աղի, պանիր

\* պանիրը աղի է

1 wrong word

պանիրը աղի ...

type correction for է

\* չէ

good.

անուշ, կարագ

\* կարագը անուշ չէ

1 wrong word

կարագը ... չէ

type correction for անուշ

\* անուշ

good.

Pattern number \* 48

[Present tense of "to drink" with object.]

ես, գարեջուր

ես գարեջուր կը խմեմ

դուք, գինի

\* դուք գինի կը խմէք

ինք, կաթ

\* ինք կաթ կը խմէ

Pattern number \* 172

["There is" with numeral in subject.]

Հոս երկրաչափ կայ: :: 7

Այո, եօթը երկրաչափ կայ:

Հոս բժիշկ կայ: :: 10

\* Այո, տասը բժիշկ կայ:

Հոս ուսանող կայ: :: 1

\* Այո, մէկ ուսանող կայ:

1 omitted space

Հոս գեղագործ կայ: :: 2

\* Այո, երկու գեղագործ կայ:

Հոս նկարիչ կայ: :: 8

\* Այո, ութը նկարիչ կայ:

Pattern number \* 184

["There is" with locative and numeral plus genitive in subject.]

սաւոր, 8

Պարտէկը ութը սաւորի ծառ կայ:

Երբան, 11

\* Պարտեզը տասնըմեկ Երբանի ծառ կայ:

Կերաս, 1

\* Պարտեզը մեկ Կերասի ծառ կայ:

Խնձոր, 7

\* Պարտեզը եօթը Խնձորի ծառ կայ

Omitted final punctuation

i wrong word

... եօթը Խնձորի ծառ կայ:

type correction for Պարտեզը

good.

\* Պարտեզը

Pattern number \* 188

[Answers to questions with "How much".]

Այս ինքնաշարժը քանի է: :: 6000

Այդ ինքնաշարժը վեց հազար տոլլար է:

Այս հագուստը քանի է: :: 800

\* Այդ հագուստը ութը հարիւր տոլլար է:

Այս սառնարանը քանի է: :: 200

\* Այդ սառնարանը երկու հարիւր տոլլար է:

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