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AUTHOR	Searle, Barbara; And Others
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ABSTRACT

This report describes the activities of the Radio Mathematics Project of the Institute for Mathematical Studies in the Social Sciences (IMSSS) during the 1974-75 fiscal year. This project is funded by AID for the purposes of (1) developing and testing a cost-effective system of radio instruction in elementary mathematics for developing countries, (2) developing a methodology for producing radio materials based on rapid feedback concerning student performance, (3) beginning a program of research on learning by radio, and (4) helping a host institution develop the capability to continue or expand the program. The second year of the project, beginning July 1974, was devoted primarily to testing the system and training teachers in Masaya, Nicaragua. These activities and their results are described in this document. (SD)

Second Annual Report
Agency for International Development

APPLICATION OF RADIO TO TEACHING ELEMENTARY MATHEMATICS IN A DEVELOPING COUNTRY

Barbara Searle, Jamesine Friend, and Patrick Suppes

with the assistance of

Dean Jamison, Juan José Montenegro Pineda, Luis Ramírez Aubert, Thomas Tilson, and Vitalia Vrooman

July 30, 1975

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INSTITUTE FOR MATHEMATICAL STUDIES IN THE SOCIAL SCIENCES

STANFORD UNIVERSITY

STANFORD, CALIFORNIA

TABLE OF CONTENTS

Introduction

The Radio Mathematics Project of the Institute for Mathematical Studies in the Social Sciences (IMSSS) has been funded by AID to design, implement, and evaluate, in collaboration with personnel of a developing country, a system for teaching elementary mathematics by radio. The objectives of the project, as described in the initial contract with AID, are to:

1. develop and test a cost-effective prototype system of radio mathematics instruction for elementary grades in a less-developed country that could, with minor adaptations, be used in many less-developed countries;

2. develop a methodology for producing radio instructional materials based on the rapid and specific reporting of previous student performance back to the materials developers;

3. begin a program of research on major variables affecting learning through radio;

4. help build capabilities in an appropriate host institution that would enable the institution to continue or even expand the project with minimal further assistance from external experts.

During its first year, July 1973 to July 1974, the staff selected Nicaragua as a project site from among the twelve countries that expressed an interest in hosting the project (Searle, 1974). In June 1974 three Stanford staff members moved to Nicaragua to join two Nicaraguans already recruited to work on the project. Shortly after July 1, 1974, an office was established in Masaya, Nicaragua. This report describes the activities of the ensuing year, during which staff was recruited and trained, and work was started with schools in the Department of Masaya.

The major activities of the year included preparing and administering an achievement test to first-grade students at the end of their school year, writing and pilot-testing a group of six radio lessons, and initiating daily radio lessons in sixteen experimental schools. By June 30, 1975, 70 taped lessons had been presented, almost half of the first-grade curriculum.

In Chapter 1 we give a brief overview of the year's activities, and indicate the ways in which our activities differed from those projected in 1974. Chapter 2 presents an administrative history of the year. Chapter 3 covers many aspects of the year's operations in the schools, but we delay to later chapters discussion of the two activities for which we are able to present analysis of data, the 1974 pilot lessons (Chapter 4) and the 1974 first-grade achievement test (Chapter 6). In Chapter 5, we examine in some detail what we have learned about teaching by radio. A preliminary cost analysis for the project is presented in Chapter 7 and Chapter 8 contains discussion of other research activities of the project. Chapter 9 concludes the report with a brief summary of our accomplishments to date and a tentative calendar for 1975-76.

Project Calendar

July 1, 1974 to June 30, 1975

July 4	Office opened in Masaya, Nicaragua
September 3 - November 13	Six lessons pilot-tested
October 22 - November 15	Achievement test administered to 44 first-grade classes
	Attitude questionnaire given to 44 teachers of first grade
February 12	First day of 1975 school year
February 10, 13, 20, 29	Weekly teacher training sessions
February 24	Project mathematics lessons started in 16 classes
March 3 - 7	Mathematics pretest administered in 16 experimental classes
March 6	Teacher training session
April 7 - 11	Mathematics pretest administered in 9 additional classes
April 10	Teacher training session
May 12	Experimental lessons started in 6 Granada schools
June 19	Teacher training session
June 30	Lesson number 70 presented in experimental classrooms

Chapter 1

Overview of the Year's Activities

Prior to establishing an operational site, the Stanford staff developed an elaborate and detailed research plan (Searle, Friend, Jamison, Suppes, Tilson and Zanotti, 1974). Although still providing guidelines for project activities, the plan has been altered in many aspects as we have become operational.

The plan called for mathematics lessons to start with the middle of first grade. Two justifications for this plan were given. The first was that the project office would be opened in June, the middle of the school year, and if we taught all of first grade, we could not start lessons until the following February. The second was that we felt that the initial stages of mathematics instruction should make heavy use of concrete materials and we felt uncertain about how to handle such teaching by radio.

For both operational and pedagogical reasons we abandoned the plan to begin project lessons in the middle of first grade. Operationally, we were unable to begin producing lessons as fast as we had hoped. We underestimated the time it would take to locate and set up an office and to recruit and train staff members. Thus, although Stanford staff arrived in Nicaragua in June, it was August before we were able to begin serious work on the writing of lessons.

The pedagogical reasons for abandoning the plan were equally important. We found from observation of first-grade mathematics classrooms that many teachers grouped students by ability and taught different material to each group, so that by the middle of the year there was a very large spread in the difficulty of topics being taught in the classroom. Thus, in the middle of the school year, some children in a classroom were still learning to count to 10 while others were doing simple multiplication exercises. It would be impossible to introduce into such classrooms lessons aimed at an appropriate level of difficulty. Rather, we felt we must pace the lessons from the beginning of the year, to diminish the wide diversity of topics being taught. (We did not feel that the disparity between the activities of the "slow" and "fast" groups was an accurate reflection of the spread in ability in the classroom, because we observed that teachers tended to spend more time with the fast group, thus continually contributing to the disparity in level of activities.) For these operational and pedagogical reasons we decided to begin lessons at the beginning of first grade and use the intervening time to experiment with methods for teaching with concrete materials and with other aspects of lesson construction.

We used the months of August through November, 1974, to observe classes, recruit and train staff, write, record and try out a set of six radio lessons, work with the computer center to develop data analysis programs, assess the mathematics achievement level of first-grade students, and recruit teachers for the 1975 experimental classes.

Curriculum development and planning for the opening of school occupied the months before February, 1975.

Our initial research plan called for pilot-testing taped lessons in six classrooms, three from rural and three from urban schools. Several factors contrived to increase this number. First, for reasons discussed later, we expanded the rural/urban classification of schools to three categories, rural, municipal, and urban, and decided to use three schools from each location. Because we were concerned about the postponement that would be caused by starting first grade lessons as late as February, 1975, we developed a plan to revise lessons immediately and present revised versions in different classrooms, one month after initial presentation. Expecting to implement this plan in February, at the end of 1974 we recruited 18 teachers to participate in pilot-testing. The revision schedule proved to be unworkable (because we did not have enough trained staff to produce two lessons a day). Nevertheless, we honored our commitment to the teachers we had chosen to participate in the project. (This year two experimental teachers share one classroom and another teacher left the district, reducing the number of classrooms to 16.)

In May, at the suggestion of the Minister of Education, we expanded the project to include six classrooms in Granada, a neighboring department. Radio lessons in Granada schools are run without direct supervision by project staff. Materials are delivered to the School Inspector, who distributes them to teachers. She also provides training for teachers, after consultation with project staff members in Masaya. Because worksheets are returned to our office, we have a method of assessing how often the taped lessons are used.

The 1974 research plan called for lesson development in three phases. During Phase A, lessons were to be pilot tested in a small number of classes, major revisions were to be made during Phase B, and a summative evaluation carried out in Phase C. Although we expect to continue using three phases, we are presently considering a rearrangement of plans for Phase B and Phase C activities for first grade lessons. Although plans for 1976 are not final, we expect to delay a major revision of the first-grade radio lessons to Phase C, broadcasting lessons already developed. These plans are discussed more fully in Chapter 9.

more fully in Chapter 9.

Chapter 2

Administrative History of the Year

During our visit to Nicaragua in March, 1974, Ministry of Education officials suggested that the project establish offices in the Instituto de Masaya, a secondary school in downtown Masaya. In the interim before Stanford staff arrived in Nicaragua, the Ministry decided that, because extensive remodelling would be necessary, the Instituto would be an unsatisfactory site for project offices. Therefore, one of the first tasks of the skeleton staff first assembled in June was to locate the project offices in a suitable building.

In less than a month we had found and moved into a pleasant three-bedroom house on the outskirts of Masaya. The house is large enough to accommodate a staff of 25. No alterations or renovations were needed except for minor work that could be done as time permitted. The Ministry of Education pays for rent and electricity; all other costs are paid by the project.

Furnishing the offices was accomplished in small steps over a period of seven months. Since the office opened in mid-fiscal year, the Ministry had no funds for purchasing new furniture until January, 1975. In the interim the office was furnished with an assortment largely collected from two sources. First, we were lent some new school furniture that was being reserved for a secondary school under construction near Masaya. This consisted mostly of small-sized student desks, but also included several typing tables and, more important, a typewriter. Also, at the Ministry headquarters we found some school and office furniture that had been damaged in the earthquake. We were given permission to use some of this, which, after repair, has proved serviceable.

These furnishings were adequate for the minimal staff during the first months of operation. In January, 1975 the Ministry provided us with a large complement of new furniture including 11 desks with chairs. With the addition of typewriters and file cabinets purchased with project funds, the office is now adequately furnished for a staff of 25.

During the same period, from June 1974 to March 1975, we gradually acquired the necessary office machines. In addition to typewriters we own a Gestetner scanner and mimeograph machine for producing worksheets; both of these were shipped from the U.S. The Xerox machine and IBM keypunch machine are both rented locally. The keypunch machine was delivered several months later than promised, causing a delay in the planned data collection procedures.

Standard office supplies--paper, stencils, IBM cards, etc.--are purchased locally with the exception of a few special items. Almost all the supplies and equipment used for radio production and the tape recorders and cassettes used in classrooms have been imported. Except for some delays in clearing customs, we have had few problems keeping the Nicaragua office supplied with equipment.

The other major and essential pieces of equipment are the four cars which were purchased in the U.S. All are Ford products: two Broncos, one Maverick, and one Econoline Club Wagon. Because of factory and shipping delays, the cars were not delivered to Nicaragua until September, 1974. Until that time we used a vehicle belonging to a staff member and two rented cars (taxis hired by the day, with driver). Except for one dented roof and one missing spare tire, the project cars arrived in good condition and have served adequately since then. We have had some difficulty in obtaining repair parts since the Ford dealer in Managua does not stock many of the parts for the models we use. At times this has caused some inconvenience. Fortunately, potentially intolerable delays in obtaining replacement parts from the U.S. have so far been avoided; twice, essential parts have been hand-carried by staff members from the U.S. whose visits coincided with the need for parts.

The vehicles are heavily used, transporting staff members who live in Managua to and from work, and during the school day, for visiting classes. Each vehicle is fully scheduled for routine school visits and unexpected transportation needs presently require a reorganization of the car schedule.

Recruiting and training staff members has occupied much of the time of the Stanford staff. The first two Nicaraguan staff members, Vitalia Vrooman, the co-director, and David Cardoza, a curriculum writer, were assigned by the Ministry in March of 1974 and devoted over half of their time between March and June to the project. These two have proved to be outstandingly good choices; both have excellent backgrounds in mathematics curriculum work. Other competent staff members have not been so easy to find. We have now the foundations of a good staff, but the effort of recruiting them has been far from trivial.

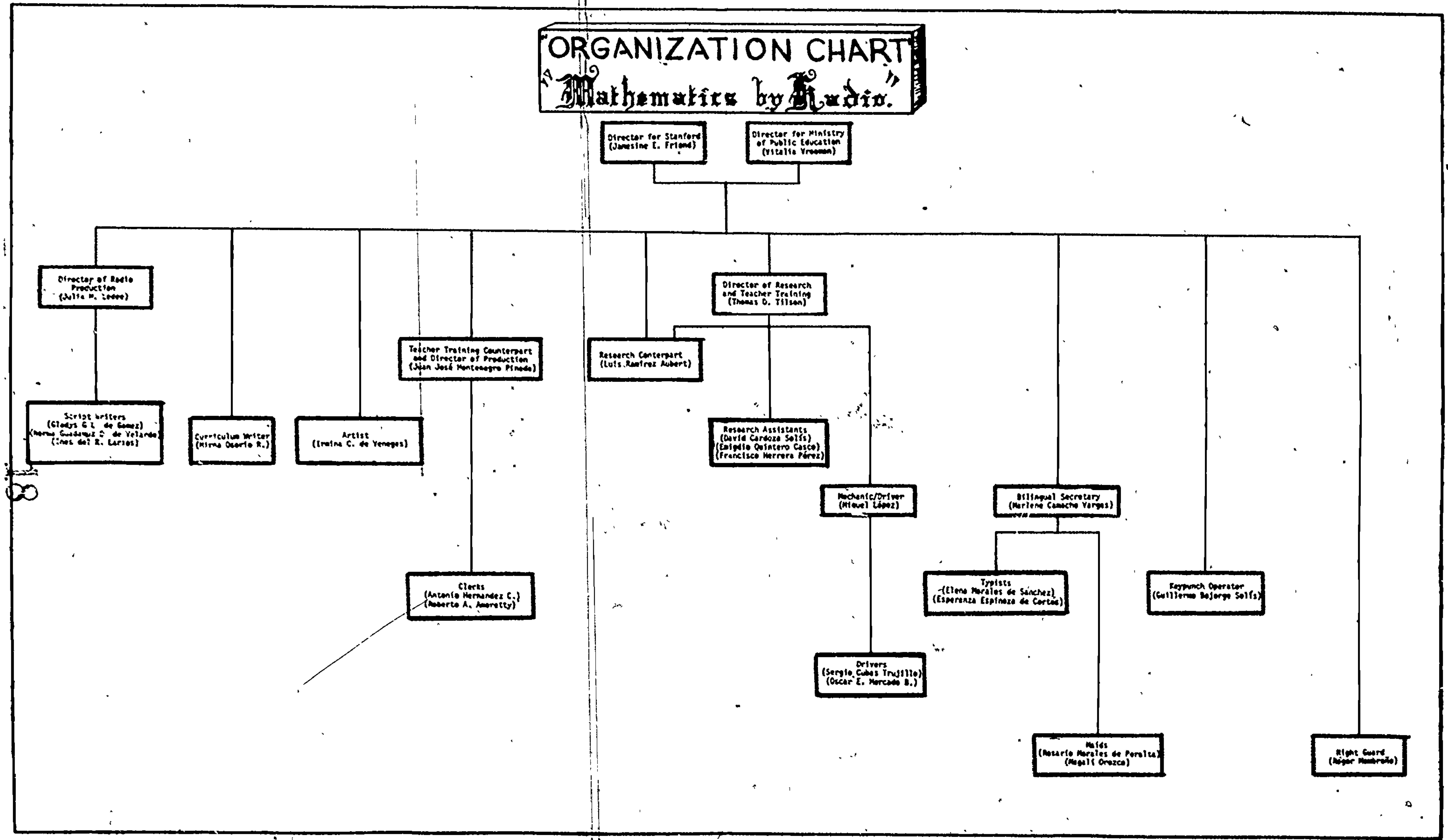
In recruiting professional staff we have looked for people with an adequate background in education who are also capable of learning new professional skills such as making classroom observations writing scripts, designing tests, and coding observational data. For tasks such as teacher training and test administration we expected to find, and did find, a higher level of incoming skills, although some training was also necessary in these two categories.

In curriculum design the problem is most severe. There are few people who have had any experience with curriculum development, and none with experience developing curriculum for radio. All of the curriculum design to date has been handled by the two co-directors and one trainee. We were fortunate to have Mrs. Vrooman on the staff--her previous experience in related curriculum work is excellent. It is not a very happy circumstance, however, to have the directors so closely tied to detailed production-line work, and we hope to gradually train other people to take over most of this work now that many aspects of it are becoming routinized. We estimate that four to six months are needed to provide adequate training for curriculum work.

Another skill that requires approximately four months of training is script writing. One person who was recruited in November to be a script writer did not become a fully productive writer until February. Another who started in February is just now, in June, doing an equitable share of the work without requiring large amounts of supervisory time. Both of these writers are quite creative and have the additional benefit of several years' experience as classroom teachers, which gives them a valuable insight into children, their interests, and their ability to understand instructions. In the process of finding two people who could be trained as script writers we have interviewed or tried out four times as many. Almost all of those whom we tried out and rejected were willing and hardworking, but lacked that elusive creativity and ability to manage the language that is so necessary in a script writer. A script production staff of three, including the Stanford staff member, is barely adequate for maintaining our present production schedule. Thus, recruiting and training script writers continues to be high on our list of priorities.

In other areas such as classroom observation and teacher training our problems have been less severe than in curriculum design and script writing. Production of materials (worksheets, teachers' guides, cassette copies) caused severe problems during February and March, the beginning of the Nicaraguan school year, but are now under good control, under the supervision of Juan Jose Montenegro, who is also the counterpart director of teacher training. Many of the research functions, including classroom testing, are handled by Luis Ramirez, the Nicaraguan counterpart for research and evaluation. At present there are 23 Nicaraguans on the staff, 11 professionals and the remainder support staff. The organization chart for the office is shown in Figure 1.

At the end of June, 1975, we feel that we have assembled a good, congenial, hardworking, and trainable staff, and have only two major unsolved problems. We still must hire and train at least one more script writer, and we must relieve the co-directors of much of the curriculum design work by expanding the capabilities of other staff members.


ORGANIZATION CHART
"Mathematics by Radio"
Director for Stanford (Jamesine E. Friend)
Director for Ministry of Public Education (Vitalia Vrooman)
Director of Radio Production (Julia M. Ledee)
Script Writers (Gladys G L de Gomez) (Norma Guadamuz C de Velarde) (Ines del R. Larios)
Curriculum Writer (Mirna Osorio R.)
Artist (Ivaina C. de Veneges)
Teacher Training Counterpart and Director of Production (Juan José Montenegro Pineda)
Clerks (Antonio Hernandez C.) (Roberto A. Ameretty)
Research Conterpart (Luis Ramírez Aubert)
Director of Research and Teacher Training (Thomas D. Tilson)
Research Assistants (David Cardoza Solís) (Emigdio Quintero Casco) (Francisco Herrera Pérez)
Mechanic/Driver (Miguel López)
Drivers (Sergio Cubas Trujillo) (Oscar E. Mercado B.)
Bilingual Secretary (Marlene Camacho Vargas)
Typists (Elena Morales de Sánchez) (Esperanza Espinoza de Cortes)
Maids (Rosario Morales de Peralta) (Magalí Orozco)
Keypunch Operator (Guillermo Bojorge Solís)
Night Guard (Róger Membreño)

Chapter 3

Operations in the Schools

In this chapter we discuss our experiences with schools, the schedule of lesson presentation adopted for 1975, teacher training, pretesting of children, interaction with school personnel, and the collection of data about schools and about student background and performance.

The project is located in the Department of Masaya, which is approximately 30 kilometers southeast of Managua. The department has an area of about 543 square kilometers, and is the smallest of the 16 departments in the country. The population is about 94,000 and approximately 30,000 people live in the city of Masaya, capital of the department.

There are approximately 100 public primary schools in the department, with roughly 170 first grade classes. The Ministry of Education characterizes schools as urban if they are located within the boundaries of a municipality, otherwise as rural. A comparison of several indices of urbanization for the ten municipalities in the Department of Masaya is shown in Table 1. Two towns, Masaya and Masatepe, stand apart from the others on almost all of the indices. They have larger populations and more paved streets, movie theaters, banks, and telephones than any of the other towns. Visits to the towns supported the conclusion suggested by the data in Table 1, namely that Masaya and Masatepe are far more urbanized than the other towns. The

Table 1

Indices of Urbanization

	Index	Masaya	Masatepe	Niquinohomo	Nindiri	San Juan de la Concepcion	La Concepcion	Nandasmo	San Juan de Oriente	Catarina	Tisma
1.	Population	30,000	6,300	2,300	2,000	1,200		2,600	600	2,000	2,200
2.	Post-primary schools										
	a. Commercial	3	0	1	0	0	0	0	0	0	0
	b. "Ciclo Basico"	0	1[b]	2[b]	0	0	0	0	0	0	0
	c. "Bachillerato"	4[a]	1	0	0	0	1	0	0	0	0
3.	Commuting time by bus to post-primary schools (in minutes)				15	15		30	20	15	40
4.	Minutes between buses to Managua or Masaya	10	30	20	10[c]	45	45	30[d]	20	20	120
5.	Percentage of paved streets	25%	30%	0	0	0	0	0	0	2 streets	0
6.	Number of movies	3	2	0	0	0	1	0	0	1	0
7.	Number of banks	5	2	0	0	0	0	0	0	1	0
8.	Number of bookstores	4	0	0	0	0	0	0	0	0	1
9.	Number of daily newspapers from Managua	2	2	2	2	1	2	0	2	1	1
10.	Number of telephones	6,500	130	28	7	2	10	2	0	2	6

[a]Includes 2 private schools.

[b]Includes 1 private school.

[c]After 10 minute walk.

[d]After 15 minute walk.

project staff therefore decided to stratify schools into three levels, calling those in Masaya and Masatepe urban, those in the other eight towns municipal, and the remainder rural.

The distribution of students among grades for the Department of Masaya for 1974 is shown in Table 2. Approximately 37 percent of the students are in first grade (this figure rises to 46 percent for rural students). The age distribution for first grade students in 30 classes is shown in Table 3. The mean age for urban students is 8.2 years, that for rural students 8.5 years.

During October and November of 1974 we selected 18 first-grade teachers to participate in pilot-testing of lessons for the 1975 school year. We obtained from the office of the School Inspector a list of teachers who were expected to teach first grade the following year and in making choices used information about teachers that had been collected from classroom observations during 1974. Several criteria were used. We wanted approximately equal numbers of teachers from urban, municipal, and rural settings and we wanted teachers who understood the nature of the extra burden being placed on them and were willing to accept it. The teachers had to be located in schools within a 40-minute drive from the project office on roads that are accessible year-round using a 4-wheel drive vehicle. A few teachers were asked because we thought they were especially good teachers of mathematics and might be able to provide us with useful feedback.

Table 2

Number of Pupils per Grade

Department of Masaya, 1974

Grade	Urban	Rural	Total
1	4,357	2,825	7,182
2	2,502	1,256	3,758
3	2,201	832	3,033
4	1,741	550	2,291
5	1,338	359	1,697
6	1,172	258	1,430
Total	13,311	6,080	19,391

Table 3

Age Distribution of First-grade Students

Test Population[a]

	Age											
	5	6	7	8	9	10	11	12	13	14	15	Total
Rural	0	11	70	69	60	24	12	14	3	0	0	263
Municipal	0	12	76	95	52	45	16	11	2	1	0	310
Urban	3	13	91	98	46	25	14	8	2	1	0	301
Total	3	36	237	262	158	94	42	33	7	2	0	874

[a] 30 randomly selected classes.

During the long vacation one teacher moved out of the district. Two of the teachers selected to participate in the program are teaching in the same classroom, an unusual situation apparently dictated by the physical layout of the school and the size of the first-grade enrollment. Thus, this year the experimental population consists of 17 teachers and the students in 16 classrooms.

During the 1974 school year all radio lessons are being recorded on cassettes and presented in classrooms using battery-operated tape recorders. We refer to these lessons here as radio lessons.

The 1974 school year began in Nicaragua in mid-February. We decided not to use radio lessons from the outset, but to provide three weeks of 'readiness' material to prepare children for the use of worksheets and familiarize them with the vocabulary and response modes the radio lessons would ask of them. For this purpose we prepared guides and used training sessions (described below) to acquaint teachers with our goals and methods for this set of pre-broadcast lessons. Although these lessons went well, we do not think they were necessary, and expect we would have had no problems had we started presenting radio lessons immediately. The material presented in three weeks of lessons could have been condensed into five radio lessons and next year we plan to do this.

For the first four weeks during which radio lessons were presented we prepared only three a week. This decision was necessitated by the inexperience of the production staff, which was simply unable to produce five lessons a week at the outset. We had not prepared lessons in advance because of the need to be free to respond rapidly to experience with the earliest lessons. Outlines were prepared for the two weekly lessons that were not taped, and the teachers' guides were used to tell teachers what material was to be covered in each lesson.

We now produce a radio lesson for each school day. Because the situation arises frequently that one or a few schools will have no classes on a day when the rest of the district is in session, we have adopted a policy of lesson presentation that simulates conditions with the radio. That is, we ask teachers not to use lessons prepared for a day when they do not meet class. They are asked not to change the schedule, and not to present two lessons in one day. Lessons are constructed with enough redundancy so that missing one day will not (we hope) reduce student performance.

Teacher training

Project teachers met weekly for the first month of school, and thereafter approximately once every six weeks. To date they have participated in six teacher training sessions. The initial set of training sessions were designed to acquaint teachers with the purposes of the project, help them become oriented to their new teaching role, allow the staff and teachers to become acquainted, explain logistical aspects of the project, such as distribution and collection of materials and the classroom observation schedule, and to present specific teaching plans for the project lessons they were being asked to teach.

Training sessions were held at the project offices after school and lasted from two to three hours. On the average, 12 of the 17 teachers attended each session. They were joined by the staff members (usually four) who had participated in planning the session and shared the task of running it. The sessions focused on the interchange of ideas and experiences, in the format of an open dialogue between all the participants, giving the teachers the opportunity to express themselves as naturally and spontaneously as possible. Several principles guided the planning of the sessions; that materials presented should be directly related to the needs of the teachers, that teachers should be active participants in their own learning experience, that they should have experience with the materials they are to teach, and that they should feel part of the process of lesson development.

Teachers participated in many different activities. During the first sessions they played the role of students for a radio lesson and worked with the materials the project had prepared for the 'readiness' lessons, developing lesson plans for their own use during this period. They designed a worksheet to help them become familiar with its structure and use. By the third session, the emphasis shifted back to the use of radio lessons and teachers spent time further defining their new role, and their specific responsibilities before, during, and after the radio lesson. In some of the later sessions, the following specific problem areas were examined in more detail; (a) classroom management concerns, such as efficient ways of distributing materials, (b) how teachers might work with children of different ability levels, especially those who were having the most difficulty keeping up with lessons, and (c) the use of materials--why the use of materials is important in teaching basic mathematical concepts, the kinds of materials they could use, and how to use them to meet specific curricular objectives.

Part of each training session was devoted to logistical concerns, discussing when materials would be distributed and collected (lesson materials for a week are distributed the preceding Thursday or Friday), how children were to number their worksheets (and the importance of having the correct student number on each sheet), and when their classes would be tested or observed. Teachers were also given practice in using the tape recorder, especially with adjusting sound levels, which they tend to set too high, resulting in distortion of the sound.

For the project, one of the most valuable aspects of the teacher training sessions has been the opportunity to obtain from teachers information about how lessons are going in their classes. The project staff has strived to maintain positive, close relationships with the teachers, not just to help ensure their cooperation, but also to encourage them to express their opinions openly and honestly. As the year progresses, they have felt increasingly free to criticize, and have given us much useful information as a result.

Classroom visitation

Of the 16 experimental classrooms, staff members observe the mathematics lesson daily in six, and once a week in five. The remaining five classes are not observed at all. We chose to maintain only limited contact with a group of classes so that we could find out what types of problems arise, how well the teacher is able to cope with the them, and whether such classes use the recorded lessons as regularly as those that are observed. Teachers of these unobserved classes have the opportunity to talk with a staff member once each week when materials are delivered and collected.

In a further attempt to examine utilization of materials in the absence of staff support, an arrangement was made with the School Inspector of Granada, a neighboring department, to present lessons in six classrooms under her supervision, without any contact with project staff. Preliminary indications are that both the unobserved classes in Masaya and the classes in Granada are using lesson materials regularly, and have not encountered unsurmountable problems with tape recorders and lesson materials.

The project method for observing classes has become more systematic as the year has progressed. At the beginning of the year an observation form was developed to record aspects of the way teachers taught project material without support from radio lessons. During the first three weeks, teachers were given a guide that included suggestions for specific activities, but allowed much flexibility, and we wanted observers to record details of what the teachers and children actually did during the lessons. The form we used was quite simple, providing for a running account of what happened in the classroom.

When radio lessons started we devised a form that identified each part of the lesson and asked the observer to comment about the following items for each segment of the lesson: whether instructions given by the radio were understood by the children, what proportion of the children participated in each activity, whether the observer thought the children found the exercises easy or hard, whether the children followed the worksheet, how the classroom teacher and children handled materials, whether the mathematics content seemed easy or hard and whether the teacher followed the instructions in the teachers' guide.

Using this form, observers were able to provide considerable qualitative information that was quite useful to curriculum specialists and script writers. However, the form did not provide quantitative data that would allow comparisons between lessons, or of one part of a lesson with another. About one month after radio lessons began we revised the observation form again and are now using a slightly modified version of this revised form. The form is designed for use with both radio and postbroadcast segments of the lesson, and uses a numerical rating, asking observers to evaluate, using a scale of 1 to 10, several factors for each portion of the lesson. The factors are the degree of interest displayed by the children, the approximate percentage of the children participating, the approximate percentage of participating children that are working independently, and a rating of how well the children appear to understand the material being presented. Observers are also asked to respond to questions posed by script writers or curriculum developers about particular segments or exercises. The observation form for each day's lesson is prepared in advance with each segment identified in such a way that the observer can recognize when it starts, and with the special questions typed on the form.

The staff maintains an on-going training program for observers. Pairs of observers visit the same class, and the two observation sheets are used during training sessions to clarify and make more reliable the use of the rating scales. Each observer participates in this exercise at least once a week.

First-grade pretest

For a first-grade pretest we chose to use a modified version of the Tests of Basic Experiences (TOBE), published by CTB/McGraw Hill, for which there is a Spanish version. We used the Level K examination, designed for use with kindergarten children, because most Nicaraguan first-grade students have had no prior school experience. The test booklet contains only pictures, with one exercise on a page. The test directions contain two types of verbal material, the general directions to the children, and the stimuli (specific directions), one for each item, to which the children respond.

The Spanish version of the test was designed for use with children in the United States, and a change in oral stimulus for a few items was necessary. One question asked the children to recognize a U. S. coin, in other cases the Spanish usage was not customary in Nicaragua. After these initial changes were made, the lessons were pilot tested in two classrooms and further changes were made in items. In addition, the general directions were substantially rewritten. These changes will be reported in detail in a forthcoming publication that will also present an analysis of the test data obtained.

The authors of the TOBE test suggest that the Level K form be administered in groups of five or six under carefully controlled conditions. We were unable to do this, but we did take special precautions to reduce the level of copying. In some classes we asked students to leave (those excused were randomly selected from the class list). In many cases, the test administrators rearranged the furniture in the classroom and changed the seating pattern of students, using books as dividers between students where this was possible. While one staff member read the instructions, another circulated through the room, encouraging children to work alone.

The test was given to 537 children in the 16 experimental schools and to 268 students in 9 schools that were randomly selected from among those schools not participating in the project. We tested this latter group to give us information about how different our experimental classes were from a randomly selected set of classes. We will posttest this same group of classes but do not plan to compare performance of the two groups because the experimental classes were not randomly selected.

Collection of data about schools and students

We have found that both the Ministry of Education and the School Inspectors Office for the Department of Masaya collect data about schools and students, and both of these agencies have been very cooperative about making information available to the project.

The Ministry of Education collects summary data from each of the sixteen departments in the country. Once a year they publish a booklet that presents some of this data. The following list includes most of the data available about primary schools. The booklet contains information on

1. the number of matriculated students per grade,
2. the number of students (by grade) that took the final examinations and the number that passed,
3. the number of deserters,
4. the school-age population,
5. the number of repeaters by age and grade,
6. the number of teachers by sex and certificate,
7. the number of schools and classrooms by type and location, public/private/municipal and urban/rural,
8. the number of teachers, by grade and location,
9. the pupil-teacher ratio by type of school,
10. a frequency distribution of pupil-teacher ratio by location of school, and
11. the number of teachers and students in unitary or multigraded classes.

The Inspector's office receives monthly attendance records

4

from the schools, and at the beginning and end of the year, matriculation figures, and pass-fail information. We have obtained the following information about the teachers and schools with which we are working.

1. Teachers

   a. type of teaching certificate
   b. level of formal study
   c. years of service
   d. age and sex
   e. marital status and number of children

2. Schools

   a. location by barrio
   b. urban/rural by municipality
   c. public/private/municipal
   d. morning/afternoon/evening sessions
   e. number of classes by grades
   f. initial matriculation by grade, sex, age
   g. number of repeaters by grade, sex, and age
   h. number that took final examinations
   i. number that passed and failed final examinations
   j. number of deserters by cause (sickness, work, conduct, or other)
   k. average monthly attendance by grade
   l. amount of furniture (desks, chairs)

Information about individual students must be collected from the school; no records are kept at the Inspector's office. We are presently collecting the following information about students, both those in the classes that were given the year-end achievement test in 1974 and those in the 1975 experimental classes.

1. Data by student for year 1 (collected in 1974 and 1975)

   a. date of matriculation
   b. sex
   c. date of birth
   d. school at which he studied last year

e. number of years (or partial years) he has attended school
f. number of years he has repeated
g. father's occupation
h. distance from home to school
i. attendance--number of days in school per month
j. whether student took final examinations
k. whether student passed the school year
l. whether student passed in mathematics
m. number of subjects student failed

2. Data by student for year 2

a. whether he retook failed examinations the following February
b. the outcome of the reexaminations
c. whether he entered school
d. what grade he entered
e. what school he entered

These data will be used in a study of the determinants of mathematics achievement, repetition propensity, and dropout propensity, which is described briefly in Chapter 8.

Relationships with school personnel

The project staff has attempted to maintain contact with others in the school district who are concerned with or interested in the project. The Inspector provided us with letters of introduction, and has asked all school directors and teachers to cooperate with the project. We keep directors of schools we work with informed of all changes that affect their schools. We also send out an information bulletin to all teachers in the Department to keep them informed about project activities.

In our contacts with teachers of experimental classes we have stressed that classroom observations and the testing program are not designed to evaluate either teachers or individual students, but are for the purpose of improving the instructional program. We try never to make evaluative comments to the teachers, except occasionally to praise them for something special. The teachers receive no report from us on how students perform, but we have discussed with them ways they can use worksheets themselves to evaluate student performance. The teachers have responded well to our approach and we have encountered none of the resistance we anticipated to our intervention in their classrooms.

Chapter 4

Curriculum Development and Production

Design and Testing of 1974 Pilot Lessons

Preliminary information about many aspects of the design of radio lessons was obtained from the administration of pilot radio lessons to first-grade classrooms. Two lessons were written, tested in three classrooms, and then completely rewritten. Four more lessons were produced and all six form the set of pilot lessons described here. These lessons were given in six classrooms during November, 1974, close to the end of the academic year.

The content of the lessons was chosen to provide a variety of topics, with at least one topic that was new to the children, presented in a coherent sequence of lesson segments.

Several types of responses (oral, written, physical, manipulation of materials) were used to find out what the children were able to do, what types of instructions were needed, and how much time to allow for responding. In addition, we experimented with reinforcement by providing answers to some questions after the students had responded.

Some portions of the lessons were designed to be handled entirely by the teachers, sc we could assess the effectiveness of our instructions to teachers. We also asked the teachers to motivate the lessons and to assist during the broadcast by encouraging the children to respond orally and by displaying a sample worksheet.

We tried to arouse interest in the lessons by using stories with lots of action and adventure, augmented by many sound effects. The same skeleton cast was used throughout the six lessons and additional characters were brought in as needed.

Lesson Content. The six lessons contained 48 segments, of which 39 were presented during and 9 after the broadcast. Segments were chosen from five strands: Number Concepts (NUM), Applications (APL), Geometry (GEO), Basic Concepts (BAS), and Addition (ADD), as shown in Table 4. Segments from the Basic Concepts strand were used to teach students to use the work sheet. (These tasks were nonmathematical, asking the students to identify common objects.) Number Concepts segments asked students to play a number game, count aloud, count sounds, write numbers from dictation, and give successors. Segments from the Applications strand covered measuring with a ruler, days of the week, and money, while Geometry segments centered around comparing lengths of lines. Addition segments contained oral arithmetic exercises. The content of all segments is indicated in Table I, Appendix A.

Response Mode. In each lesson approximately half the segments required written responses, except for the first lesson, which had only one such segment. Other segments required oral or physical responses. Oral responses included constructed responses to arithmetic exercises (What is 2 plus 3? What number comes after 17?), responses to mathematical questions phrased as choices (Which is longer, a broom or a pencil? Which is worth more, a 5 cent coin or a 10 cent coin?),

Table 4

Number of Pilot-lesson Segments by Strand and Lesson

Strand	Lesson 1	2	3	4	5	6	Total
Number concepts	6	4	5	3	2	1	21
Applications	1	2	1	2	4	4	14
Geometry	1	0	0	1	2	0	4
Basic concepts	0	2	1	1	0	0	4
Addition	0	0	0	0	3	2	5
Total	8	8	8	8	9	7	48

responses to general-interest or organizational questions (Children, are you ready?), and recitation (rote counting, naming days of the week). Written responses were made on worksheets. Some were constructed (Write the answer: how much is 5 + 2?), some were multiple choice (Circle the empty glass), and some were drawn (Draw a line longer than the one shown on the worksheet).

Physical responses were mostly in the "mando mando" game--"mando" means "I command" in Spanish--in which childeren followed the instructions of a leader (Clap your hands, raise two fingers). In addition to worksheets and pencils, the only materials used were cardboard rulers.

Almost all segments requiring written responses contained five exercises (some of those presented after the taped lesson had 6 or 8 exercises).

Results. In general, the children responded actively and with apparent enjoyment. They gave oral responses readily, even answering rhetorical questions (which we now try to avoid). At first the teachers were quite active in eliciting oral responses, but this seemed unnecessary and we now discourage the practice.

Because we anticipated that children would have difficulty in following oral instructions, we made frequent use of repetition. We found that this often confused and rarely helped the children. They followed instructions well, experiencing difficulty only when the instructions were ambiguous or the content too difficult. However, occasionally an unexpected noise drowned out an essential word. This caused problems only when children were working individually on worksheets, and we now repeat only key words or phrases that provide instruction for written work. In one lesson we used a "cartoon" voice to give exercises. Only a small proportion of the students understood the voice and we have dropped that practice.

The children's high level of listening skills when instructions were presented contrasted strongly with their response to stories in the pilot lessons. For the most part they appeared bored and uninterested in the characters. When questioned after the lessons, students indicated that they did not follow plots. We have decreased both the amount and the complexity of story material used in lessons.

The children had more difficulty using the worksheets than we had anticipated. They often marked answers in the wrong spaces and we have redesigned the worksheet to add an identifier for each section. Before presenting an exercise we ask the children to put a finger on the identifier that marks the space for the answer.

We experimented with the amount of time allowed for various types of responses, and developed the following set of guidelines:

oral response to a question with an obvious answer	2 sec.
counting 1 to 5 bottle tops	5 sec.
circling one choice among 2 or 3 pictures	5 sec.
writing a 1-digit number	8 sec.
drawing 1 to 3 circles	12 sec.

In several segments we tried to supply reinforcement by announcing the correct answer after the children were given time to write a response. This procedure seemed to confuse many children and not to help the others. We have not found a successful substitute and do not presently give reinforcement for written answers. (We asked the children to cross out rather than erase an answer they wanted to change. They much preferred to erase, with a wet finger if no eraser was available.)

Teachers seemed to be receptive to the program. Some teachers who thought the children would have difficulty listening to and obeying instructions from a recording machine repeated many of the questions, thereby shortening the time allowed for the children to respond. We now urge teachers not to repeat unless there is a noise or distraction that prevents children from hearing the tape.

For the first version of the first two lessons we wrote lengthy and detailed teachers' guides, but these proved to be confusing; a much briefer guide format was used for the six lessons, and is still in use.

We turn now to an examination of student response data, which are reported for all segments requiring written responses. During the lessons we made no attempt to inhibit cooperative answering or "copying", which certainly occurs. (We once observed a child marking two worksheets while her friend searched for a pencil.) Cooperative answering inflates scores (at least for easy exercises) but there remains considerable variation in scores.

The number of students taking each lesson ranged from 155 to 186. The mean percentage correct for segments requiring written responses is shown in Table 5. (The identifier L1-4 is for lesson 1, segment 4). On the basis of previous experience we consider a performance level of between 80 and 90 percent correct to be optimal for first-grade children (lower levels are too discouraging). The performance level for the pilot lessons was acceptably high, falling below 70% correct for only two segments (L2-7 and L5-9).

Evidence for learning appears when we examine scores for three segments presenting the same task, which had not been previously taught. Exercises in segments L2-8, L3-8, and L4-7 asked students to measure pictures of objects (which varied in length from 3 to 10 centimeters). As seen in Table 5, the percentage correct increased from 71.0 to 88.3.

Although the overall performance level was quite high, there was substantial variation for lessons and classes. Mean percentage correct for each lesson for the six classes are presented in Table 6. Class 4 performed well consistently, while Class 2 performed poorly for the entire set of lessons. Other classes showed occasional high or low scores. This variability is not unexpected, but presents difficulties when trying to adopt the appropriate difficulty level for lessons and exercises.

Preparation of the pilot lessons gave the staff an opportunity to work out many of the procedures that would be necessary for producing

Table 5

Performance on Pilot Lesson Segments

Lesson & Segment	Strand	n	Mean Percentage Correct	S.D.
L1-4	NUM	169	88.8	3.2
L2-4	BAS	174	78.0	25.3
L2-5	NUM	174	80.1	3.2
L2-7 [a]	BAS	174	66.9	4.5
L2-8 P	APL	174	71.0	4.5
L3-4	BAS	186	71.5	10.0
L3-6	NUM	186	73.2	3.2
L3-7	GEO	186	88.0	8.4
L3-8 P	APL	186	78.3	5.5
L4-2	GEO	173	94.5	4.5
L4-4	NUM	173	70.1	8.4
L4-5	BAS	173	83.9	4.5
L4-6	GEO	173	83.7	.0
L4-7 P	APL	173	88.3	5.5
L5-4	APL	155	85.5	5.5
L5-7	ADD	155	78.8	8.4
L5-8 P	APL	155	80.6	7.7
L5-9 P	APL	155	49.1	4.5
L6-3	ADD	174	83.8	3.2
L6-4	APL	174	76.9	16.4
L6-6	APL	174	83.5	7.7
L6-7 P	APL	174	91.4	.0

[a] P means presented after the taped lesson (postbroadcast).

Table 6

Mean Performance on Pilot Lessons by Class

Percentage Correct

Class	Lesson 1	2	3	4	5	6	Mean
1	89.2	80.0	73.2	92.7	60.9	88.7	80.8
2	78.0	68.8	61.4	65.1	58.0	62.3	65.6
3	83.3	80.7	89.9	91.3	81.1	88.4	85.8
4	100.0	85.2	90.7	92.0	85.2	94.6	91.3
5	92.0	54.4	79.8	89.8	70.3	86.0	78.7
6	87.6	73.9	74.8	79.1	75.0	79.3	78.3
Mean	88.4	73.8	78.3	85.0	71.8	85.6	80.1

lessons on a tight schedule. The results lead us to the following general conclusions about the design and use of radio lessons.

1. Children are most attentive to radio lessons when they are responding actively.

2. Mathematical activities are more engaging than the stories in our programs for first-grade children.

3. Rhetorical questions are answered by the children; such questions should be used only sparingly and time must be allowed for responses.

4. Children listen to instructions and, in most cases, repetition is not needed.

5. Children can learn new topics from the radio lessons.

Curriculum Structure

Project lessons are based on the mathematics curriculum specified by the Nicaraguan Ministry of Education. A thorough revision of the primary mathematics curriculum was completed in 1973, under the direction of Mrs. Vitalia Vrooman, who is now Nicaraguan Director of the project. An abbreviated version of the new curriculum outline for First Grade appears in Figure 2. The list of topics is that of a typical 'modern mathematics' program. Except for the inclusion of formal work on multiplication and division, the outline closely resembles those prepared in the United States. It is also very similar to outlines we have examined from other developing countries, an illustration of the great commonality in primary school mathematics curriculums throughout the world.

First Unit: Basic Concepts (2 weeks)

size, height, position, width, quantity, weight

Second Unit: Sets (4 weeks)

set, element, comparing sets, equality, inequality

Third Unit: Systems of Counting (8 weeks)

counting up to 99, ordinals, place value

Fourth Unit: Addition and Subtraction (4 weeks)

addition and subtraction as inverse operations, sums, differences to 18, addition and subtraction of 2-digit numbers without carrying or borrowing

Fifth Unit: Multiplication and Division (3 weeks)

Readiness work, multiplication combinations up to 27, division with dividends up to 15, divisors of 2 to 5

Sixth Unit: Common Fractions (2 weeks)

halves, thirds, and fourths

Seventh Unit: Money (2 weeks)

monetary unit--el cordoba, 5, 10, 25, 50 centavo coins, equivalencies

Eighth Unit: Measures (5 weeks)

length, volume, time, weight, pairs and dozens

Ninth Unit: Geometry

point, line, plane, curved and straight lines, angles, figures with 3, 4, more sides

Figure 2. Nicaraguan first grade curriculum: condensed version of outline prepared by the Ministry of Public Education.

There are several reasons for adopting the Nicaraguan curriculum as the basis for project lessons. First, the curriculum is certainly satisfactory as a basis for the radio lessons. Second, the Ministry has expended much effort in the last several years revising the curriculum and retraining teachers. We feel that teachers will be less resistant to a change in mode of presentation of lessons if the curriculum is not changed (once again) at the same time. Finally, the use of the same curriculum in experimental and control classes facilitates evaluation of the radio lessons.

Some changes in emphasis and some reorganization of the Nicaraguan curriculum have proved necessary in structuring the radio lessons. As shown in Figure C1, each topic in the Nicaraguan curriculum is allotted a specific period for instruction. Teachers customarily follow these guidelines, presenting all instruction on a topic in a single block of time. Because of the demonstrated superiority of distributed practice we chose not to follow this procedure, instead dispersing instruction on each topic throughout the school year.

The radio curriculum, which serves as the basis for radio lessons, is divided into topics or strands. For first grade the strands are Basic Concepts, Number Concepts, Addition, Subtraction, Applications, Geometry, and Measurement. For each strand a set of behavioral objectives was formulated, defining the behavior expected of a student who has successfully completed the first-grade instructional program. The behavioral objectives defined for the first-grade radio curriculum are shown in Appendix D. For illustrative purposes we present several of the objectives for the Number Concepts strand in Table 7.

The objectives specify only what the student should be able to do at the end of the year, and each objective must be subdivided in order to serve as a guide for instruction. The resulting instructional classes span the entire curriculum, but they are not disjoint. Thus, the first several instructional classes obtained by subdividing behavioral objective NUM-1 (see Table 7) are

NUM-1-1	Count aloud from 1 to 5
NUM-1-2	Count aloud from 1 to 10
NUM-1-3	Count aloud from 1 to 13
NUM-1-4	Count aloud from 1 to 20.

Class NUM-1-2 includes class NUM-1-1, which in turn is included in NUM-1-3, and so on.

Sometimes instructional classes are defined that do not appear in the list of terminal objectives, but are used to build requisite skills. For example, the first three instructional classes for objective NUM-8 (writing numerals) are

NUM-8-1	Copy numerals from 1 to 3
NUM-8-2	Copy numerals from 1 to 5
NUM-8-3	Write numerals 1 to 3 from dictation.

Copying numerals appears as an intermediate but not as a terminal task.

In addition to defining the instructional classes for each behavioral objective, the curriculum specialist must decide how often each class is to be sampled and how to relate the development of objectives to each other. For example, the instructional classes that

Table 7

Selected Behavioral Objectives for Number Concepts

NUM-1 Rote counting by ones

When asked to count aloud, the child will count, "one, two, three,..." until stopped (no farther than 100).

NUM-4 Rote counting by tens

When asked to count aloud by tens, the child will count; "ten, twenty, thirty,..." until stopped (no farther than 100).

NUM-6 Reading numerals

Given a printed numeral (0 to 100) the child will say aloud the name of the number.

Example: "What number is this?"

48

NUM-7 Selection of numeral

Given a set of 2 to 10 printed numerals (0 to 100) and the oral instruction to select a specified numeral the child will indicate the correct numeral by pointing or circling.

Example: "Circle the 41"

58 0 4 41 40 14

NUM-8 Writing numerals

Given an oral instruction to write a specified numeral (0 to 99) the child will do so.

Example: "Write the number 87."

teach writing numerals from 1 to 3 must be presented before the student is asked to write 3 in response to another type of exercise.

In the case of first-grade mathematics, we have good criteria for determining an appropriate ordering of classes. The subject matter itself is hierarchical; in many cases concepts and exercise types build logically on one another. Moreover, at the Institute at Stanford we have developed several elementary-level mathematics courses, two of them using computer-assisted instruction. We have collected over the years a large body of performance data, which provides additional guidelines for the ordering of instructional classes based on the relative difficulty of exercise types. These results are reported in Suppes (1972, 1974), Suppes and Morningstar (1970), and Suppes, Searle, and Lorton (in press).

The instructional classes are used to define lesson segments, as described below. For a lesson segment we must also specify the mode of presentation and the student response mode. An exercise may be embedded within a story or a realistic situation familiar to the children, or it may be presented abstractly, without embellishment. Students may be asked to answer orally or in writing.

The strands and instructional classes specify the content of the curriculum, but not the relative emphasis given to each topic. Decisions about allocation of time were made using the Nicaraguan curriculum guidelines and the results of investigations of relative importance of topics in mathematics texts written in the United States (Suppes, Searle, and Lorton, in press). The proportion of time devoted to each topic for five lesson blocks is shown in Table 8 for the first half of first grade. For the first lessons, exercises from the Basic Concepts and Number Concepts strands are used, in roughly the ratio 1:4. As new topics are added the time spent on Number Concepts exercises decreases, reaching 55 percent by Lesson 85. The percentages shown in Table 8 are derived from the number of segments from each strand that was used in each lesson.

Lesson Production

We turn now to the process of translating curriculum specifications into scripts for radio lessons, preparing auxiliary lesson materials, reproducing materials and distributing them to schools. The entire process requires close cooperation between the curriculum specialist, the writers of scripts and teachers' guides, and the artist to ensure that the final lesson accurately reflects the intent of the curriculum specialist. For purposes of discussion we separate the process into four steps.

1. The curriculum specialist designs an individual lesson.
2. The script writer translates the specifications for the lesson into a radio script.
3. To produce the lesson,

   a. the artist prepares the worksheet,

Table 8

Percentage of Instruction Devoted to Each Strand

in 5-Lesson Blocks

Lesson range	Strand Identifier				
	BAS	NUM	ADD	APL	SUB
1-5	31	69			
6-10	20	80			
11-15	12	74	2	12	
16-20		88	10	2	
21-25	5	67	20	8	
26-30		67	27	6	
31-35	3	60	37	10	
36-40	3	60	21	16	
41-45		65	19	16	
46-50		63	27	6	4
51-55		51	26	17	6
56-60		60	18	18	4
61-65		73	9	3	15
66-70		49	33		18
71-75		64	16	7	13
76-80		54	6	14	26
81-85		55	14	5	26

b. a teacher training expert prepares the teacher's guide, and

c. the recording artists record the lesson, under the direction of the radio specialist.

4. The components of the lesson (worksheets, teacher's guides) are reproduced and distributed to schools.

Step 1: Design of an individual lesson

A radio lesson is specified by selecting an appropriate group of instructional classes from several strands. Each instructional class provides the instructional content of a <u>lesson segment</u>, and the segment description specifies the exercises, the mode of presentation, and the mode of response required. Each lesson is comprised of from six to ten segments, presented by radio and by the teacher in the post-broadcast period. For example, Lesson 18 (near the beginning of first grade) has seven radio segments and three postbroadcast segments. The segment descriptions, as they appear in the outline for script writers, are shown in Table 9. (The original outline and the other materials associated with Lesson 18 are presented in Appendix E.)

Table 9 illustrates the variety of topics and response modes that may be incorporated in a single lesson. However, as is evident from the outline, topics are not chosen at random, but in relation to one another. Segments 1 and 7 give different types of practice with roughly the same addition combinations. Segment 4 provides practice in writing the numerals needed in Segment 5, and so on. An outline

Table 9

Segment Descriptions for Lesson 18, Grade One[a]

Segment number	Presented by	Description
1	Radio	Show the addition facts 2+2, 3+2, 4+1, 1+2 using fingers. "How much is 2 plus 2?"
2	Radio	Rote count from 1 to 20, two times.
3	Radio	Give successors orally for 5, 8, 7, 9, 10. "What number comes after 5?"
4	Radio	Write numerals from dictation. "Write the number 4 (3, 5, 2, 6)."
5	Radio	Write the successors of 2, 1, 4, 3, 1. "Write the number that comes after 2."
6	Radio	Ordinals 'first' and 'second', oral, then written response, using drawings. "There is a plate on the first table. What is on the second table? Circle the first table (second basket, second box, first dish)".
7	Radio	Readiness for addition, drawing. "Draw 2 balls on the first line. Draw 1 ball on the second line. How many are there in all?" (oral response) (1+2, 1+3, 3+2, 2+2)
8	Teacher	Reading numerals from 1 to 7 (printed on worksheet). "Circle the 3 (6,2,4,7,5)."
9	Teacher	Read numerals 1 to 9 on cards (prepared by teacher).
10	Teacher	Count objects, from 1 to 10 (materials chosen by teacher).

[a] Translated from Spanish.

like that shown in Table 9 (with additional information concerning response modes, timing, and worksheet layout) provides the basis from which script writers produce a script for the radio lesson, curriculum writers produce the teachers' guide, and the artist prepares the worksheet.

Step 2: Translation of lesson specifications into a radio script

Before the lesson outline reaches its final form, the script writer reviews it and makes a preliminary plan for the script. This process often suggests revisions, which the curriculum specialist and the script writer make together. Then the script writer prepares an outline for the projected script and reviews this with the curriculum specialist. No dialogue is written until the two specialists have come to full agreement about the outline.

Although the lesson is initially structured by segments, these are not delineated in the lesson script and the writer is encouraged to embed the mathematics in story contexts in those lessons where stories are used. The placement of songs and games, unless these are included in the outline, is also at the discretion of the script writer. The translation of a segment description into radio script is illustrated in the following excerpt (translated from Spanish) from Lesson 18, which is based on the description for Segment 1 (see Table 9). The Spanish version of the script can be found in Appendix E.

The setting is a carnival, with happy background music. The radio characters--Lulu, Carlos, and Lobo--are laughing and talking excitedly about how many things there are to see and buy. Lobo (a character who often makes mistakes) asks the classroom children to help him count all the things he bought.

Lobo: First I got 2 balloons, then 3 more...I think 2 plus 3 equals 5.

Carlos: Wait. Let's see if he's right. Attention, children. Hold up two fingers on one hand...and hold up three fingers on the other hand. How many fingers are there? (pause) That's it--2 plus 3 is 5.
And what else did you get, Lobo?

Lobo: I got 2 caramels, and then 2 more.

Carlos: Children, tell me--how much is 2 plus 2? (pause) That's it--4. But let's prove it. Hold up 2 fingers on one hand, and on the other hand hold up 2 more. Now tell me, how many fingers are there? (pause) Very good--2 plus 2 is 4.

Lobo: I also got Roman candles. First I got 3 Roman candles, and then 2 more.

Carlos: Okay, children--how much is 3 plus 2? (pause) Now let's prove it with our fingers. Hold up 3 fingers on one hand, and hold up 2 on the other. How many fingers are there? That's right--3 plus 2 is 5.

(Carlos does the same thing with 4 + 1 (balls) and 1 + 2 (flags).)

Lobo: Three flags--one for you, Lulu, one for you, Carlos, and one for me! Oh, how many things I have now!

In asking the children to 'prove' the correctness of their answers, the instructional program is teaching them a method for finding a sum of two numbers that does not depend on memorization.

When the first draft of a script is completed, the writer reads it to a group of staff members including those involved with curriculum, teacher training and classroom observation. The listeners use their knowledge of children to comment on the clarity of instructions, the level of difficulty of the language used, and the interest likely to to be generated by the stories and characters. The script is then rewritten (if necessary) in response to the criticisms of the staff.

The penultimate version of the script is timed and any necessary adjustments are made. It is then ready for recording. We have found in Nicaragua that an experienced script writer, following the process we have described, can write two or three 20-minute scripts a week.

Step 3: Lesson production

While preparing the lesson outline, the curriculum specialist makes a sketch of the student worksheet that will accompany the lesson. The artist makes a preliminary drawing which is checked for accuracy and clarity, and then is redrawn in final form. Most worksheets use both sides of the paper and, especially for early first grade, contain many illustrations. We employ an artist full time to produce five worksheets a week. The worksheet for Lesson 18 is reproduced in Appendix E.

A list of suggestions about the contents of the teachers' guide is prepared together with the lesson outline. A curriculum writer uses these to produce a 2-3 page guide for each lesson, describing the instructional content and the teacher's role in the postbroadcast activities. (Appendix E contains the teacher's guide for Lesson 18.) Suggestions for optional activities are also included. We find that one writer can write five guides each week, with some time left for visiting classrooms.

The final step in lesson production takes place in the recording studio. We use professional recording artists--three people play all the parts. We use prerecorded sound effects and songs and produce an entire tape in real time. That is, unless some flaw in the tape is found, it is not edited after the recording session. All music and sound effects are taped at the same time as the spoken parts and the timing of pauses for student responses is precisely controlled. We find that an experienced staff--the artists, the producer, and the radio technician--takes about an hour to produce a 20-minute tape.

Step 4: Reproduction of materials and distribution to schools

We use an electronic scanner to make a stencil of the worksheet prepared by the artist, and all materials are mimeographed at the project office. During the pilot-testing phase materials are delivered to classrooms weekly.

This completes the description of the process of lesson construction, but a few remarks remain to be made. We consider it crucial that every person involved in lesson production observe the use of the lessons in the classroom. Thus we require all writers (of curriculum, scripts, or guides) to visit classes regularly, and encourage visits by other staff members (artists, research staff, even secretaries) as well.

We want to emphasize also that close cooperation and mutual understanding between the curriculum specialist and the script writer is essential for the production of good instructional radio programs. The training of each of these professionals does not predispose them to working well together. The curriculum specialist talks about precisely specifying goals and objectives, while the script writer values intuition and literary creativity. To forge a working relationship between these two takes much skill, understanding, and good will.

Guidelines for Script Writing

As we gain experience with writing and producing lessons, the project is developing guidelines that incorporate the results of our experience. A few of these will be mentioned here.

When children recite--numbers, days of the week, and so on--it is necessary to establish a rhythm for them. It is also important to tell them clearly where to start. We have taught the children to wait for the radio to tell them to start and we establish the rhythm with drum beats or beating sticks.

Children often try to anticipate what the radio is going to say, and start to respond before an instruction is complete. For example, in one lesson we intended to tell the children to hit the table using their elbows. The phrase "using your elbows" came at the end of the instruction and before the children heard it they were using their hands. Rephrasing the instruction, "Use your elbows to hit the table three times" avoids the difficulty.

We exercise care in the use of sound effects and music. We try to use music that is familiar to the children, and open and close each program with the same theme music. No background sound is played during the presentation of instructions and exercises and silence is maintained while children are given time to respond to exercises.

When children are asked to start an activity they must be told when to stop. They do not automatically sit down after being asked to stand up, and if we fail to tell them to put down their pencils when they complete an exercise, they usually keep them in their hands and are often distracted. We find it is important to indicate the end of an activity. If we don't the children seem to wait for something more to happen.

The vocabulary for instructions is carefully controlled and standardized. For example, we always use the word "tachar" (cross out) rather than the phrase "hacer una cruz" (make a cross). We always ask the children to "encerrar en un circulo" (enclose in a circle) when we want them to draw a circle around a figure. The standard set of phrases was chosen after consultation with several curriculum experts and teachers. We allow more complicated vocabulary and syntax for story components of the lesson than for instructions and exercises.

Tests Embedded in the Curriculum

A ten-item test is included in every fifth lesson, and is designed to obtain information about student performance on earlier parts of the curriculum. (This information is used during the process of curriculum development and evaluation.) The embedded tests are not described to teachers as tests, but as reviews. We chose not to tell the teachers the students were being tested to prevent any differential treatment of students during these segments.

The structure of the tests is presented in detail in Appendix F. Briefly, test items are exemplars of instructional classes that are sampled from strands in roughly the same proportion as the strands are represented in the curriculum (see Table 8). The population of classes sampled includes only those defining terminal objectives, not intermediate objectives. Thus, the instructional class described above, "copy numerals from 1 to 5" would not be included in the population of classes sampled for embedded tests. The population of classes is further restricted to those that have been administerd by radio and for which the task is independent of context (that is, does not depend on a preceding exercise).

Diagnostic Segments

In response to teachers who expressed an interest in evaluating student progress we are experimenting with the use of selected segments as diagnostic tests. That is, we suggest to teachers that they can identify students who are having difficulty with a concept by examining responses to the identified segment. Thus, we suggest they examine responses to L62-6 (Segment 6 in Lesson 62) to assess performance on the concept "greater or less than", L65-6 for successors, and so on. Suggestions for additional activities for students who need help are included in the teachers' guides accompanying these lessons.

Chapter 5

Structure of Radio Lessons

We turn now to a consideration of aspects of the design of radio lessons, problems that have arisen, and an assessment of our experience to date.

Types of Student Response

We distinguish at least three types of responses that we ask of children. They may speak aloud, they may write, or they may respond physically. For each of these an observer can determine whether a child is responding. (There is a fourth type which we do not use--asking the children to think of a response without communicating it.) We will discuss each of the three response types in turn.

Characters in a radio program may talk either among themselves or directly to the listeners. We make a careful distinction between these two modes. When characters are talking to each other, we expect children to listen without responding. When a character talks directly to the children, we expect and plan for the children to respond. In this way a type of dialogue can be established between a radio character and the children. Student responses are highly structured, and there is, of course, no complex interaction; nevertheless the process engages the attention of the children.

Oral responses include such 'conversations' between the children and radio characters, and also answers to exercises presented in both free-response format and multiple-choice format. An example of an oral exercise in multiple-choice format is

> I am thinking of two objects--a box and a ball.
> Which is round?

An oral exercise in free-response format, presented abstractly, is

> What is 5 plus 10?

and presented in story form,

> Juan earned 5 centavos yesterday and 10 centavos today.
> How much did he earn altogether?

Recitation--rote counting, reciting the days of the week or months of the year--is also used. As another type of oral response, children sing songs. A song is taught by having radio characters sing it several times at its first presentation and then at least once in several successive lessons. After only a few repetitions the children are able to join the singing. Many of the songs we use are about mathematics. Lyrics are written by the project staff and set to music and recorded by Nicaraguan musicians.

Physical activity is a second kind of response that the radio characters ask of the children. Children may play games--one game has them patting their knees, their shoulders and their cheeks a specified number of times--or they may be asked to hold up fingers, handle materials, or point to pictures or numbers on the worksheet.

Finally, the children are asked to write on the worksheet. Once again, exercises are presented either in multiple-choice or in free-response format. In the former, children mark the correct choice, while in the latter they may draw pictures or write numerals or words.

We are experimenting to find an appropriate level of activity for the children. Our present lessons are much faster paced and ask for more responses than the initial lessons we pilot-tested. At present the lessons ask for an average of two to three responses per minute, and our classroom observations suggest that this rate of responding could be increased. The children appear inattentive while radio characters talk to each other, but as soon as a character adopts the tone of voice used to talk to the children they become attentive.

Maintaining children's attention is, of course, a necessary prerequisite for effective radio lessons. Our initial view was that we would use stories to engage the children, and embed mathematical work in a story context to maintain interest. Pilot tests of lessons designed in this way, using kindergarten and first-grade children in California and first-grade children in Nicaragua, have convinced us that the mathematical activities are intrinsically interesting to the children and do not need story support, as long as the children are asked to respond frequently. Thus, our view of the role and importance of stories has changed markedly.

At present we are experimenting with the use of lessons that have songs, games, and oral and written exercises, but no stories. These lessons are presented alternately with lessons containing story episodes. Both types of lessons use the same main characters, but

65

subordinate characters appear only in the lessons containing stories. Our current view is that stories are useful for presenting mathematical material in a realistic setting but, at least for young children in the classroom, are not needed for maintaining interest level.

Providing Reinforcement

We have experimented with various methods of reinforcement. In a pilot test of five recorded lessons, using California kindergarten and first-grade children, we found that few children changed their written answers, or even appeared to listen, when the radio lesson provided a correct answer several seconds after an exercise was presented. We found first-grade children familiar with the procedure for checking a group of written answers, but this procedure gives no reinforcement with oral exercises, because the children do not remember what the exercise was.

To date, the most successful method we have found for providing knowledge of results is to ask the children to respond orally. In this way, children who do not know the correct answer learn from those who do. This method can be used in conjunction with written exercises by first asking the children to write their answers, then to say them aloud. Because of its effectiveness in enhancing learning, we consider reinforcement an important aspect of the lessons. We do not feel satisfied that we are providing enough reinforcement in the most effective manner, and we continue to experiment with this aspect of the radio lessons.

Using Concrete Materials

There is almost universal agreement today that lower primary-level students should use concrete materials while studying mathematics. However, there are many obstacles to the use of materials during radio lessons. Although the best Nicaraguan teachers use materials, the practice is limited, and therefore unfamiliar to many teachers. Nicaraguan schools have no money available for the purchase of materials, nor any central method for distributing even those that might be obtained free. Thus, each teacher is individually responsible for their provision.

Problems of an entirely different sort arise when children are asked to handle materials themselves. The objects are dropped, misplaced, and argued over. The fast pacing of the radio lessons does not allow time for coping with such problems. Even more serious problems arise when the teacher has failed to distribute the materials, or has handed out the wrong number, and the children are unable to follow the directions given by the radio.

Notwithstanding these difficulties, we are attempting to use materials--for the most part, bottle caps--during radio lessons, with considerable success. We ask the teachers to distribute a specified number of caps (to date we have used no more than 10) to each child before the lesson starts. The caps are used early in the lesson and then the radio asks the children to leave them alone. The children respond well to this instruction. The primary use of these small numbers of caps is to illustrate addition and subtraction. Counting larger sets is delayed until the postbroadcast period. We have found the bottle caps to be noisy and somewhat unwieldy and have plans to try other materials next year.

The use of materials during the postbroadcast segment of the lesson has fewer disadvantages because the flexibility of the classroom permits the teacher to cope with difficulties that arise. We encourage teachers to provide concrete experiences for students and will use the teachers' guide to suggest materials and activities.

The Segmented Structure of Lessons

The research literature on the effect of practice on learning supports the proposition that skills need to be practiced regularly to be maintained, and that distributed practice is superior to massed practice. Thus, a specified amount of practice is more valuable when it occurs in short, frequent sessions than in longer, less frequent sessions. In a classic paper that summarized 48 unpublished studies, Wilson (1925) concluded that drill should have the following attributes in order to be effective:

1. It should be on the entire process.
2. It should come frequently in small amounts.
3. Each unit should be a mixed drill.
4. It should have a time limit.
5. Examples in a unit drill should be in order of difficulty.
6. It should include verbal problems.
7. It should facilitate diagnosis.

With these experimental results in mind, we have developed a lesson structure that provides for several different topics in each lesson, as well as different types of activities and different modes of responding. Once a topic has been introduced, it reappears at regular intervals, sometimes in the same, sometimes in different contexts, providing continuing practice for the children. Weekly tests (included to provide information for curriculum development) are not identified to either students or teachers as such, but are presented as reviews. These sets of exercises provide a further opportunity for students to practice skills already learned.

Differential Learning Rates

Coping with differential learning rates is the most difficult problem facing the developer of curriculum for radio. During this first experimental year we are concerned primarily with exploring the extent of the problem. How large is the spread in achievement at the beginning of the year, and as the school year progresses? We will use results of tests embedded throughout the radio curriculum to examine this question. Do children who are performing very well or very poorly appear to lose interest in lessons? We will rely on classroom observers and teachers' reports to answer this question.

We have given some thought to ways of providing different levels of instruction to different children during broadcasting. In our testing program we developed exercises that had different printed materials associated with a single set of oral instructions, allowing children who were listening to a common set of instructions to work different exercises. We think this method holds promise for allowing children to practice skills at different levels of difficulty. Providing postbroadcast materials for children of different ability levels would also contribute to differentiating instruction.

Allocation of Instruction Between Radio and the Classroom Teacher

We are presently investigating the question of allocation of teaching responsibilities between the radio and the classroom teacher. At the beginning of the school year we put a large number of exercises into the curriculum for the teacher to handle, teaching children how to use identifiers and how to find their way around the worksheet. We asked the teachers to use a strictly specified vocabulary so that the children would learn the same words and phrases that they would later hear in the radio lessons. However, some teachers did not understand why they were asked to use exactly the listed words and phrases and therefore did not follow directions while others substituted alternate expressions that seemed appropriate. We think these exercises would have been more effectively taught by radio. On the other hand, group activities involving a variety of materials are clearly handled best by the teacher.

We can make some generalizations about who should teach what. The radio is better than the teacher for

rote-counting and other types of recitation,
fast-paced oral drill,
songs,
teaching students to follow directions,
teaching precise technical vocabulary.

The teacher does better with activities that require

- a variety of materials,
- individual supervision (such as the introduction to the task of counting objects),
- group discussion.

We are not sure who does best with such topics as

- measurement,
- applications of arithmetic,
- development of problem-solving abilities.

Summary

We continue to experiment with the format of the radio lessons. We have given particular attention to the instructional aspects of the lesson. We have been quite successful in the presentation of instructions--our first-grade students are able to follow directions so that throughout a lesson they use the appropriate part of the worksheet. The instructional portions of the lessons keep the attention of the children and most of the children respond correctly to most of the exercises. We are concerned with the problem of maintaining interest throughout the year, and continue to investigate ways of increasing the entertainment value of the non-instructional portions of the lesson.

Chapter 6

1974 First-grade Achievement Test

The 1974 testing program had two purposes, to measure student performance at the end of the school year on first-grade curriculum objectives, and to determine both the extent of performance differences between rural and urban students and the range of variation among classrooms. A multiple matrix-sampling design, in which each item is given to only a subset of students and each student takes only a subset of the items, was used. This design tests a large number of items, providing more information than a design requiring that each student answer each item; this advantage is partially offset by less stable estimates of student performance, leading to less accurate comparisons between groups of students.

A pilot test was developed and given to approximately 90 students in two classrooms. After modification the test was administered to all students in 44 classrooms. The test was developed in the following steps:

1. The equivalence classes that defined the curriculum to be tested were chosen.
2. The structure of the test and the number of items needed were determined.
3. A procedure for sampling equivalence classes was chosen and implemented.
4. The chosen equivalence classes were assigned to test forms.
5. A test item was written to represent each equivalence class.

The method outlined was followed quite closely in the construction of the pilot test. Exceptions will be noted as we describe the process in detail.

Definition of the Appropriate Curriculum

The universe of achievement test items is called the test curriculum. It is not identical to the curriculum which forms the basis for radio lessons (radio curriculum). In constructing the test curriculum, the appropriate topics are divided into strands, and then each strand is divided into equivalence classes, sets of items that have structural features in common. Each equivalence class is defined explicitly in terms of such item characteristics as the arithmetic operation, the exercise format (for presentation and for response), the size of the numbers, and so on. The equivalence class structure partitions the entire curriculum into disjoint sets of exercise types.

Two sources of information about the first-grade mathematics curriculum were used to choose the strands and the equivalence classes within each strand appropriate for a first-grade achievement test. These are the curriculum guide prepared by the Ministry of Education, described in Figure 2 (page 45), and our observations of the topics teachers were presenting in the classroom.

The strands in the test curriculum are listed in Table 10. Number Concepts topics include counting to 100, reading and writing integers and simple fractions, place value, size comparisons for both

Table 10

Distribution of Equivalence Classes Among Strands in Curriculum and Test

Strand	Number of Classes		
	Test curriculum	Proposed pilot test	Actual pilot test
Number Concepts	218	35	21
Addition	113	19	17
Subtraction	71	16	16
Multiplication	45	10	9
Division	11	5	5
Geometry	26	5	2
Applications	70	20	10
Total	554	110	80

integers and fractions, and the use of ordinal numbers up to 'tenth'. Because some teachers were teaching concepts more advanced than those specified by the Ministry curriculum guide, the Addition and Subtraction strands were extended to include problems with 'carrys' and 'borrows' and addition and subtraction of fractions. As shown in Figure 2, multiplication and division are considered first-grade topics.

Geometry includes 'readiness' topics such as the concepts of shape, similarity, position and length, and the Applications strand covers money, linear measure, pairs and dozens, time, and word problems. The test curriculum consisted of 554 equivalence classes distributed among strands as shown in Table 10.

Structure of the Test

The pilot test and the final test had the same structure except for the number of items. The test had three parts, none of them overlapping. Part A was prepared in one form, and was given in all classrooms. Part B was prepared in five forms and all students in a classroom received the same B form. Part C was prepared in five forms, and these were assigned randomly to students within each class, so that in each classroom roughly equal numbers of students worked on each C part. Each student received a single test booklet, which included the appropriate combinations of all three parts.

Test items were of two types. For some items, part or all of the content of the exercise was presented orally. For others, only the instructions were presented orally--the exercise itself was printed. For the first type of item, all students in a classroom must receive the same item. Thus, such items could not be included in Part C of the test. For items of the second type the test administrator could read instructions that apply to exercises with different content. ("Now work the next exercise" is the simplest instruction of this type.) These items could appear on all parts of the test. Because some items were unsuitable for use in Part C, it was not possible to assign items randomly to test parts.

In the pilot test, each form of each part contained 10 items. Thus, there were 10 Part A items, 50 Part B items, and 50 Part C items, for a total of 110. To obtain these items it was necessary to sample 110 equivalence classes from the test curriculum. These classes were distributed among strands as shown in Table 10 in the column labeled Proposed Pilot Test. The proportion of classes for each strand roughly corresponds to that of the test curriculum as a whole.

Results of the Pilot Test

A trial run of the entire test as described here would have required 5 classrooms, one for each B form of the test. However, because time did not permit such extensive testing only two classrooms were tested. Thus, eight forms--Part A, two forms of part B and all five forms of Part C--were tested. The 10 different test booklets used contained 80 items, distributed among strands as shown in Table 10 in the column labeled Actual Pilot Test. Each test booklet contained 30 items, 10 from each part. The number of students who took each of the eight forms and the resulting mean scores are shown in Table 11. Data for individual items are presented in Table II of Appendix A.

The distribution of item scores is shown in Table 12. Item scores ranged from 0 to 94.5 percent correct, with a mean of 34.6 percent correct and a standard deviation of 26.4. The median score was 27.8 percent correct. Table 13 shows the mean percentage correct and the range of scores for items from each strand. Results are shown separately for integers and fractions because error rates for these are markedly different. The scores suggest that few curricular goals are being met satisfactorily in these two classrooms. To give the reader a sense of the performance levels observed, Table 14 displays all of the items from equivalence classes from the Addition strand (using integers), with the associated percentage correct. The item shown in quotation marks was given orally.

Administration of the pilot test revealed several shortcomings in the testing procedures. There was much cooperative answering, especially where students sat at tables or long desks. Some test questions were worded in such a way that students answered orally instead of in writing. The pilot test proved to be very long--administration took about an hour.

On the basis of the pilot testing experience, the guide for administering the test was revised to include special instructions about rearranging seating patterns to decrease cooperative answering. The length of the test was shortened from 30 to 21 items by reducing

Table 11

Performance on Eight Subtests of Pilot Test

Part	Form	n	Mean Score[a]
A	1	91	5.8
B	1	41	4.4
B	2	50	6.1
C	1	17	2.3
C	2	18	2.0
C	3	18	2.1
C	4	20	2.3
C	5	18	2.6

[a] Maximum score = 10.

Table 12

Distribution of Item Scores for Pilot Test

Percentage Correct	Frequency
0	6
1 - 5	3
5.1 - 10	7
10.1 - 15	6
15.1 - 20	5
20.1 - 25	11
25.1 - 30	5
30.1 - 35	2
35.1 - 40	5
40.1 - 45	4
45.1 - 50	5
50.1 - 55	3
55.1 - 60	3
60.1 - 65	3
65.1 - 70	3
70.1 - 75	1
75.1 - 80	2
80.1 - 85	1
85.1 - 90	2
90.1 - 95	3

Table 13

Proportion Correct on Pilot Test by Strand

Strand	Number of items	Mean percent correct	Range of percentages
Numeration	21	53.6	5.6 - 94.5
Integers	19	55.2	5.6 - 94.5
Fractions	2	37.6	17.1 - 58.0
Addition	17	33.2	0 - 70.0
Integers	13	42.6	5.6 - 70.0
Fractions	4	2.8	0 - 5.6
Subtraction	16	21.3	0 - 52.7
Integers	12	27.0	5.0 - 52.7
Fractions	4	4.2	0 - 11.8
Multiplication	9	21.4	5.6 - 38.9
Division	5	10.8	0 - 22.0
Geometry	2	68.2	44.4 - 92.0
Applications	10	36.0	5.0 - 84.0

Table 14

Pilot Test Items Ordered by Difficulty

Addition of Integers

Item	Percentage Correct
2 + 1 = ___	70.0
3 + 2 = ___	66.7
24 21 +41	58.2
6 + 10 = ___	55.5
5 + 9 = ___	54.9
2 0 + 3	50.0
160 +530	50.0
"How much is 13 plus 4?"	43.9
20 + 7 = ___	35.3
10 + 4	23.5
38 + 55	22.2
60 + 60 = ___	16.7
64 + 8	5.6

to 7 the number of items from each part. As shown in Table 15, the topics of addition and subtraction of fractions, and division were entirely eliminated from the test curriculum. Small changes made in the distribution of items are shown in the table. The total number of equivalence classes sampled in the final test was 77. Test items are shown in Appendix B.

Selection of the Classrooms to be Tested

A list was made of all first-grade classrooms, stratified by region (urban, municipal, rural). A classroom was considered eligible for selection if there were 15 or more first-grade children matriculated. From each stratum 10 classes were chosen at random. The classrooms were selected from each school without replacement in order to ensure a wider distribution of schools (except for the municipal stratum, which had only eight schools).

In addition to the 30 randomly chosen classes, 14 were tested for special reasons. Six classes had already taken some experimental radio lessons and we were interested in how these classes handled the test. The 18 teachers who would use radio lessons in 1975 had already been chosen and we wanted data on how their students performed. Five of the 18 teachers taught classes that had been selected in the random assignment, and five more taught classes that had already used radio lessons (mentioned above). The classes of the remaining eight teachers were also tested, bringing the total of non-randomly selected classes to 14--these eight and the six radio classes. In all, 1241 students

Table 15

Comparison of Content of Pilot and Final Achievement Tests

Strand	Number of Items: Pilot Test	Number of Items: Final Test
Numeration		
Integers	19	24
Fractions	2	5
Total	21	29
Addition		
Integers	13	11
Fractions	4	0
Total	17	11
Subtraction		
Integers	12	12
Fractions	4	0
	16	12
Multiplication	9	4
Division	5	0
Geometry	2	5
Applications	10	16
TOTAL	80	77

were tested.

Each of the thirty teachers selected at random was notified in advance of the test by a letter from the Inspector to the school director. The remaining 14 teachers were told about the test by staff members, who were in contact with them regarding other aspects of the project. All teachers were assured that the test would not be used to evaluate them or individual students but that the data would be used to guide curriculum development and evaluate the project activities.

Test Administration

Tests were administered by two staff members. One read the instructions, while the other taped the testing session and acted as a monitor. While the children were being tested the teacher was asked to fill out a short form for each child giving background information including age, sex, and years in school.

The test took 30 minutes to administer (including a short break). About 45 minutes before and 10 minutes after the testing period were spent on administrative matters. Examiners reported many of the usual problems encountered when testing first-grade students--the tendency to answer aloud, confusion about following directions, and so on. These problems seemed unusually severe because of the novelty of the test situation for these students. They had never experienced any of the following: people from outside coming in to give them a test, printed tests, the exercise presentation formats used in the test, handing out of pencils, mathematics exercises presented orally (requiring written response), a test with a variety of mathematical operations presented, and the tape recording of classroom activities. In many classrooms children seemed bewildered by the situation. Although children had difficulties with the test situation, and we must certainly keep these in mind when inspecting test results, it is important to note that for four of the 77 exercises the percentage correct was over 90. Thus, at least for some exercises, almost all the children were able to respond correctly.

The examiners noted that the six classes that had just completed taking the experimental radio lessons seemed to find the test examination situation much less confusing. The format for the test was quite similar to that used for worksheets during the lessons, and the examiners felt that the radio lessons had provided some training in those skills needed to respond successfully during the test.

Test Results

Data for individual items are presented in Table III of Appendix A. The mean number correct for each part of the test is shown in Table 16 (data are for 1241 students from 44 classes). Scores for the A and B forms of the test are higher than those for the C forms. It is possible that the exercises in the C parts were harder. It is also possible that the reduction in cooperative answering (because children had different forms of the test) is responsible for the somewhat lower

Table 16

Performance on Eleven Subtests of Final Test

Part	Form	n	Mean score[a]	Standard deviation
A	1	1241	4.51	1.98
B	1	246	4.07	1.53
B	2	265	4.60	1.54
B	3	223	4.45	1.50
B	4	240	3.95	1.86
B	5	267	3.70	1.93
C	1	248	2.79	2.15
C	2	255	2.37	1.86
C	3	243	1.92	1.58
C	4	246	3.15	2.14
C	5	249	2.09	1.87

[a] Maximum score = 7.

scores.

The structure of the test provided an opportunity to assess the extent of cooperative answering. Each test booklet was organized so that questions 1, 2, 6, 13, 14, 17 and 18 were from part A, questions 3, 4, 7, 8, 11, 12, and 21 were from part B, and questions 5, 9, 10, 15, 16, 19, and 20 were from part C. The examiner led the children through the first 15 questions on the test, so that all children worked on the same question at the same time. For example, for question 5 (Part C), children were told "Read the numbers carefully. Write the numbers that are missing." The child had printed on his test booklet one of five exercises, depending on which C form he had.

A child who copied an answer from his neighbor ran the risk of copying a correct (or incorrect) answer for an exercise different from the one printed in his test booklet. It seems reasonable to conclude that a child copied from a nearby paper when his response is correct for an exercise from a different form. The complexity of the questions supports this conclusion. For question 5 the number of children who apparently copied is shown in Table 17. The numbers along the diagonal show the number of students who gave the correct answer to the exercise they were given. The numbers off the diagonal show the number who gave the correct answer for an exercise on a different form. For question 5, 80 children, approximately 9 percent of the number who responded incorrectly, gave the correct answer to an exercise from a different form.

Table 17

Extent of Cooperative Answering

on Question 5[a]

Form student took	Form for which students response was the correct answer				
	1	2	3	4	5
	Number of students				
1	104	4	3	3	5
2	9	47	2	1	7
3	4	1	40	7	1
4	4	4	2	122	6
5	9	5	0	3	52

Note. About 250 children took each test form.

[a] Question 5: "Read the numbers carefully. Write the numbers that are missing."

Form 1: 30 40 50 __ __ __ __ __

Form 2: 2 4 6 __ __ __ __ __

Form 3: 5 10 15 __ __ __ __ __

Form 4: 72 73 74 __ __ __ __ __

Form 5: 8 7 6 __ __ __ __ __

Performance on test items summarized by strand is shown in Table 18. Percentage correct for the five geometry readiness items ranged from 73.0 to 98.9. (Two of these items are shown in Table 19.) The high scores for these items provide confirmation that students were able to understand directions and respond correctly when they knew the answer.

The range of performance is shown for all strands in Table 19. The performance level was quite low for addition and subtraction items; only slightly more than half the students responded correctly to the easiest items. Approximately 44 percent of the students responded correctly to the easiest multiplication exercise.

Items from the Applications strand included word problems presented orally and in written form. The oral exercises required a free-format response; the written exercises were in multiple-choice format. Word problems (customarily presented in written form) are considered very difficult for young children. However, we have long suspected that children would find such problems easier if they were presented orally. (For some positive experimental results on the reasoning abilities of young children when problems are given orally see Suppes, 1965.) The results shown in Table 20 support this supposition. The percentage correct ranged from 49.6 to 71.3 for five word problems presented orally. (Note that 71.3 percent is higher than the performance on any of the computation items--see Table 19.) On the other hand, performance on written word problems ranged from 5.4 to 40.2 percent

Table 18

Proportion Correct on Final Test by Strand

Strand	Number of items	Mean percent correct	Standard deviation
Numeration	29	57.0	22.4
Integers	24	56.6	23.1
Fractions	5	58.6	20.8
Addition	11	45.4	15.0
Subtraction	12	32.4	13.9
Multiplication	4	33.3	9.2
Geometry	5	89.4	11.1
Applications	16	40.2	21.2

Table 19

Items with Highest and Lowest Percent Correct on Final Achievement Test by Strand

Strand	Highest		Lowest	
	Percent correct	Item	Percent correct	Item
Numeration	91.46	"Write the number 7."	16.46	"Write the numbers that are missing." 72 73 74 __ __ __ __ __
Addition	67.71	"How much is 5 plus 1?"	11.76	38 + 55
Subtraction	60.00	"How much is 6 minus 3?"	7.62	42 - 5
Multiplication	43.62	2 X 5 = ___	25.00	9 X 10 = ___
Geometry	98.87	"Circle the longest ladder." (3 choices)	73.03	"Circle the glass that is on the right."
Applications	71.30	"Manuel had 4 buttons to play with. Playing with another boy he lost 3. Write the number of buttons he has left."	2.88	"Write the hour the clock says." (10:30)

Table 20

Performance on Word Problems

Comparison between Oral and Written Problem Presentation

Presentation and response mode	Required arithmetic	Percent correct
Oral, free response	3 + 2 = ___	65.9
Oral, free response	3 + 2 + 2 = ___	70.2
Oral, free response	4 - 3 = ___	71.3
Oral, free response	2 X 4 = ___	49.6
Oral, free response	6/2 = ___	52.4
Written, multiple	5 - 3 = ___	31.1
Written, multiple choice	6 + 1 = ___	36.1
Written, multiple choice	5 + ___ = 6	5.4
Written, multiple choice	4 + 2 = ___	40.24
Written, multiple choice	3 + 3 = ___	35.7

	Mean	Standard Deviation
Oral	61.9	10.2
Written	29.7	14.0

correct. Since these exercises were presented with three answer choices, the expected percentage correct by chance is 33.3.

Examination of Student Errors

An examination of the types of errors made by students on the achievement test provides information that can contribute to designing the radio lessons. It is important to identify those aspects of the curriculum that children are not mastering, and to take particular care in teaching them by radio. We found that students had more difficulty with conceptual, as compared to computational, aspects of the curriculum.

Students often added the numbers presented in an exercise, instead of subtracting or multiplying as appropriate. The frequency of these errors is shown for nine subtraction exercises in Table 21 and for four multiplication exercises in Table 22. For the exercise, 5 - 3, 27 percent of the errors were of this type, and for the exercise 5 X 1 (written vertically) the response, 6, was almost as frequent as the correct response, 5. These results suggest that many students have failed to master the conceptual task of identifying the correct operation. The prevalent practice in the classrooms of Masaya of limiting instruction to one arithmetic operation at a time probably contributes to the students' difficulty.

Students seem to have less difficulty identifying the operation when exercises are presented orally. One exercise, 6 - 3, was presented both orally and in written form. The percentage correct for oral presentation was 60, compared with 25 for the written form, and the use

Table 21

Frequency of Use of Wrong Arithmetic Operation:

Addition Instead of Subtraction

Item	Number of Students Who Took item	Subtracted correctly	Added (correctly)
Oral			
6 - 3 =	265	159	9
28 - 2 =	240	104	9
Written			
5 - 3 =	1241	618	169
6 - 3 =	239	60	30
13 - 8 =	255	72	10
72 - 1 =	246	78	19
10 - 7	249	54	30
90 - 10	245	63	27
84 - 21	243	87	29

Table 22

Frequency of Use of Wrong Arithmetic Operation:

Addition Instead of Multiplication

Item	Number of Students Who: Took item	Multiplied correctly	Added (correctly)
Written			
2 X 5 =	243	106	35
5 X 1	249	96	72
9 X 10 =	248	62	23
32 X 3	267	70	25

of the wrong operation was three times as frequent for the latter. The frequency of use of the wrong operation was also very low for word problems presented orally. For the subtraction exercise 4 - 3 in story context, 159 of 223 responses were correct and only two students answered 7. For the multiplication exercise 2 X 4 in story context, 119 of 240 responses were correct, and one student responded with 6.

The most frequent error for operations with zero was to respond with the number zero. For the exercise, 3 + 0, of 246 children, 103 answered 6, 34 answered 0. Similarly, for 6 - 0, 88 of 248 children answered correctly, 43 responded with 0.

When writing two-digit numerals, first-grade children in the United States often reverse the digits. The same is true of our sample of Nicaraguan first-graders. When asked to write 15, 83 percent of the children responded correctly; writing 51 for 15 accounted for 10 of the 38 errors. Similarly, writing 35 for 53 accounted for 11 of 89 errors.

Students performed poorly on the task, "Write the number that comes before X." For three exercises in which X was a two-digit number, percentage correct ranged from 28 to 41. From 15 to 23 percent of the students gave the successor rather than the predecessor of the number. In contrast, 79 percent of the students correctly gave the successor to 29, and only 1 percent incorrectly gave the predecessor.

Comparison of Students from Different Regions

An important aspect of our testing program was to compare performance of students from urban, municipal, and rural schools. For this purpose we obtained for each student an estimated score for the 77 items of the entire test. The method used was adapted from that of Kleinke (1972) and a full description appears in Appendix C. In brief, the estimated score is obtained by adding together the scores for a student on the parts of the test he took, the mean scores (for all students) on the parts of the test the he did not take, and an adjustment for the student based on the difference between his own scores and the mean scores on the parts of the test he took. The maximum possible estimated score is 77, the total number of exercises tested. The mean estimated score for all (1241) students was 37.1; mean scores for classes ranged from 23.5 to 47.2. Scores for all classes are presented in Table IV, Appendix A.

Neither the comparisons using estimated scores nor those using scores obtained on individual parts of the test showed a significant difference in performance between students from different regions. Means and standard deviations of estimated scores for different student groups are shown in Table 23. The lack of a performance difference between urban and rural students is quite surprising. Of the possible explanations, we were able to test one--the effect of age. The age distribution for urban, municipal, and rural students in the test population was shown earlier in Table 3 (page 21). The mean age for urban students is 8.2 years while that for rural students is 8.5 years, not significantly different. An alternative hypothesis is that the

Table 23

Summary Statistics Using Total Scores Estimated by

Kleinke Procedure

Student group	n	Mean	Standard deviation
44 classes	1241	37.10	12.76
10 urban classes	301	37.24	12.47
10 municipal classes	310	36.42	13.00
10 rural classes	263	34.24	12.70
total 30 classes	874	36.05	12.77
6 radio classes	157	40.13	12.34

urban and rural environments of the Department of Masaya may not be sufficiently different to produce the differences typically found.

The groups of students who took the pilot radio lessons attained the highest mean test score (see Table 23). This may reflect their nonrandom selection, or may in fact result from the test-taking practice afforded by the radio lessons.

The results of the administration of the mathematics achievement test suggest the following general conclusions about first grade students in the Department of Masaya in Nicaragua.

1. Most children, even though unfamiliar with the testing situation, are able to respond to test exercises.

2. Test results are contaminated by cooperative answering.

3. Children perform well on items that test general knowledge.

4. Children perform poorly on most items that are characteristic of the formal mathematics curriculum.

5. Children have more difficulty with conceptual than with computational aspects of the curriculum.

6. Children perform better on arithmetic items presented as word problems than on those presented formally.

7. There is little difference in performance between children from urban, municipal, and rural schools.

Chapter 7[a]

An Early Assessment of Costs

The purpose of this chapter is to provide an early assessment of what project costs have been and can be expected to be. Much firmer evidence is presently available for programming costs, of course, than for implementation costs. The first section of this chapter summarizes the cost elements of the project--central project costs, program production costs, transmission costs, and reception site costs--then presents a cost function for the project and average costs based on that cost function. The next section discusses the results of the cost analysis, with some of their implications.

Cost Structure of the Project

In this section we identify the cost components for the Radio Mathematics Project (RMP) and construct from them cost functions for the project. The costs fall into four categories--central project, program preparation, transmission, and reception site--and we first present information on those basic costs; as the project is in its early stages, some of these costs, particularly those dealing with reception, are estimated rather than observed. The project relies more heavily than do most on expatriate technical assistance, and for this reason programming costs in particular are relatively high. We thus also

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[a] This Chapter was written by Dean T. Jamison of Educational Testing Service, a consultant to the project.

briefly discuss the cost implications of lower levels of expatriate technical assistance in the future.

Cost Elements

Central project costs. We divide our central project costs into three major categories--start-up, administration, and research.

The RMP commenced radio program production in Masaya, Nicaragua, in February, 1975; costs incurred prior to that time were for project planning, personnel moving and orientation, initial equipment purchase, and settling in. We thus treat those costs incurred prior to February, 1975, as being start-up costs that should be annualized over the lifetime of the project. Table 24 shows start-up costs incurred at Stanford University and in Masaya. (Note: all costs are in 1975 U.S. dollars.)

The next aspect of central project costs is that dealing with administration. For many of the staff involved, it is difficult to separate precisely central project administration effort from other functions; at Stanford the other function is principally research, in Masaya it is principally radio program production. The estimates of time allocation that we use are, then, simply the best estimates of the project staff. Table 25 summarizes annual project administration costs based on these best estimates; the total is close to $60,000 per year.

The final category of central project costs is general research, which is a major purpose of the project. The research costs listed

Table 24

Start-up Costs (through February, 1975)

I. Start-up cost of project at Stanford

Salaries	$57,819	
Staff benefits	9,830	
Travel in USA	7,182	
Computer at Stanford [a]	24,441	
Consulting	2,400	
Equipment and supplies	3,832	
Indirect costs	49,587	
Subtotal		$155,091

II. Start-up cost of project in Nicaragua

Salaries [b]	29,532	
Benefits	5,020	
Travel	8,395	
Moving costs (household and car)	20,164	
Allowances [c]	24,305	
Consulting	900	
Expendable supplies [d]	23,753	
Equipment [e]	23,394	
Indirect costs	41,464	
Subtotal		176,927

Table 24, continued

III. Start-up cost totals

A. Total start-up cost	$335,000
B. Annualized start-up cost (over 20 year project lifetime)	
1. at 0 discount rate	16,800/yr.
2. at 7.5% discount rate	33,000/yr.
3. at 15% discount rate	54,000/yr.

[a] The computer was used for the production of reports, but for essentially nothing else during this period.

[b] Salaries are for expatriate staff.

[c] Allowances include housing allowance, post-differential allowance, and children's education allowance.

[d] Expendable supplies breaks down as follows:

office supplies	3,632
books	770
postage and freight	6,085
minor equipment (tape recorders, etc.)	4,124
Nicaragua expenses	9,139

[e] The equipment includes four cars, a mimeograph machine, an electronic scanner for making stencils, and a calculator with statistical functions.

Table 25

Project Administration Costs[a]

I. Annual costs of project administration at Stanford

(all figures given include direct and all indirect costs[b])

Project coordinator	50% of full time	$14,600	
Principal investigator	6% of full time	3,100	
Secretary	50% of full time	7,000	
Administrative services (covered by indirect costs)	15% of full time	0	
University functions--purchasing, shipping, accounting (covered by indirect costs)		0	
Telephone, office supplies, etc.		4,400	
Computer time		4,600	
Travel to Nicaragua for administrative purposes (25% of four trips)		1,400	
Subtotal			$35,100

II. Annual costs of project administration in Nicaragua

Expatriate advisor	33% of full time	$15,200	
Nicaraguan project director	50% of full time	5,000	
Secretary (bilingual)	100% of full time	3,500	
Subtotal			$23,700

III. Total annual costs of project administration $58,800

[a] Costs incurred in cordobas are exchanged into U.S. dollars at the rate of 7 cordobas per dollar.

[b] Indirect costs at Stanford University are 47% of base costs.

here do not include formative research for program development; those costs appear with other program development costs. Table 26 shows annual expenditures on research at the present time (1975); these costs may be expected to decline as the project becomes operational.

Program production costs. The RMP is currently producing programs at a rate of about 150 20-minute programs per year. The first year of program production (CY 1975) is being devoted to programs for Grade 1; the second year will be devoted to revision of Grade 1 programs and initial preparation of Grade 2 programs. Thus, a single year's activity will involve both production of a set of about 150 programs, and the revision of an earlier set of 150; the output of a year's effort can thus be considered to be a produced and revised set of programs. Production here includes all steps required to plan, prepare, and put on tape the radio script as well as preparation of the student worksheet materials and the teachers' guide.

Table 27 summarizes the cost of preparing 150 lessons; the total is $160,000. This yields a cost of $1,070 per 20-minute lesson or $3,200 per hour of produced material. This is far higher than previous costs of production of instructional radio in developing countries, which results from a number of factors. First, and relatively unimportant, this figure includes cost of preparation of worksheets and teacher guides. Second, preparation of programs requiring frequent student response (40 to 50 responses per 20-minute lesson) is probably intrinsically costly. Third, careful formative

Table 26

Research Costs[a]

Item	Annual Amount	
Principal Investigator (17% of full time)	$ 9,200	
Project Manager (half-time)	14,600	
Statistician (half-time)	7,200	
Programmer	18,600	
Two graduate student assistants	10,800	
Consultants	5,900	
Telephone, office supplies	1,800	
Computer time	41,000	
Travel to Nicaragua (7 trips)	9,600	
Total		$118,700

[a] All figures include indirect costs of 47%

Table 27

Cost of Preparing 150 Radio Lessons

Item	Annual Cost
Recording costs	$ 12,600
studio time, $14/lesson artists and technicians, $42/lesson director, $28/lesson	
Scriptwriting	41,200
2 full time equivalent Nicaraguans $430/mo. each 1 full time equivalent expatriate $3000/mo.	
Curriculum design	16,200
1/2 full time equivalent Nicaraguan $570/mo. 1/3 full time equivalent expatriate $3700/mo. 1/2 full time equivalent secretary $260/mo.	
Artist for design and preparation of student worksheets	3,500
1 full time equivalent $290/mo.	
Preparation of teachers' guides	3,000
1/2 full time equivalent writer $500/mo.	
Management	19,700
1/2 full time equivalent Nicaraguan $580/mo. 1/3 full time equivalent expatriate $3200/mo. 1/2 full time equivalent secretary $260/mo.	

Table 27, continued

Item	Annual Cost
Formative evaluation	$ 55,600
1 full time equivalent Nicaragua $430/mo.	
1 full time equivalent expatriate $3200/mo.	
data processing costs $1000/mo.	
Support and facilities	8,200
rent $290/mo.	
utilities 90/mo.	
maid 60/mo.	
guard 90/mo.	
transportation 150/mo. (exclusive of vehicle purchase)	
TOTAL COST	$160,000
TOTAL COST PER LESSON	1,070

evaluation is costly. Fourth, much of the cost is for expatriate technical assistance, the presence of which more than doubles the cost of production over what it would be if the same volume of production were achieved by Nicaraguan nationals. (If expatriates were replaced by nationals, the $160,000 annual cost of Table 27 would drop to $71,000; this would reduce the cost per lesson to $470.)

Assuming a 10-year lifetime for a completed and revised lesson, the annualized cost of having a lesson available (assuming a $1,070 initial cost) is $107 if one assumes a 0 discount rate, $160 if one assumes a 7.5% discount rate, and $213 if one assumes a 15% discount rate.

Transmission costs. Our estimate of transmission costs is based on the tariff of Radio Corporacion, a private broadcasting station whose transmitter covers much of Nicaragua. Their charge per 20-minute slot between 5:00 a.m. and 9:00 a.m. is $14.50; between 9:15 a.m. and 11:45 a.m. it drops to $11.50. There is a 10% discount for a one-year contract, which would be advantageous for the RMP if such contracts allowed for less frequent than daily use. For subsequent calculations we assume a cost of $13.00 to broadcast a 20-minute lesson.

Reception site costs. The present (1975) reception sites utilize cassette players because the small number of sites in the first developmental year fails to justify use of broadcasting. Current reception costs are thus little guide to future ones, and the costs presented below simply reflect present project estimates. The cost estimates we present attempt to include all elements of cost associated with operational introduction of the RMP, including teacher training costs, supervision costs, and printed material costs.

Table 28 categorizes reception site cost estimates into three parts. The first part consists of costs common to an entire school, in this case supervision costs; assuming 3 participating classes per school and 35 students per class, supervision costs come to $.74 per student per year. This number is, of course, highly sensitive to the number of supervisor visits per school per year, and it will be important, as the project progresses, to ascertain what an adequate minimum number is. The second cost category consists of those costs common to a classroom; these costs are estimated to be $38 per classroom per year or $1.09 per student. A total of $32 out of the $38 classroom costs are for teacher training and the radio set, both of which would presumably not be increased with additional curriculums. Possibilities for savings here include sharing of radio sets among classrooms and providing teacher training less frequently than annually. The third category of costs is for student materials; these are estimated to cost $2.00 per student per year. Utilizing less than one page per day of worksheet material would result in substantial cost savings.

Cost Function for the RMP

Our cost function for the RMP will be constructed to give annualized total cost, TC, as a linear function of two independent

Table 28

Reception Site Costs (per 150 Lessons)

I. Costs Common to Entire School		$ 78.00
supervisor visits (N is number of supervisor visits per school per academic year; assumed cost per visit is 1 day of supervisor time at $11 plus transportation at $2.)		
We assume N = 6.		
II. Costs Common to Classroom		38.00
1. radio set at $50 with 5-year life time	$12	
a. annualized cost at 0% = $10/year		
b. annualized cost at 7.5% = $12/year		
c. annualized cost at 15% = $15/year (table use 7.5% discount rate)		
2. batteries[a]	5	
3. teachers guide (100 pp)	1	
4. teacher training (10 hours per year at $2/hour)	20	

[a] This assumes an average of 10 hours of playing life per battery costing $.35; these battery lifetimes are within the range of those cited in a recent Consumer Reports survey (v. 40, July, 1970, pp. 436-439).

Table 28, continued

III. Costs Individual to Students		$ 2.00
1. blank paper (0 - 1/2 pages per lesson; assume 40 pages per year at 1/4 cent per page)	$ .10	
2. workbook (1/2 to 1 page per lesson; assume 150 pages per year at 1 cent per page	1.50	
3. miscellaneous supplies	.40	

IV. Cost Summary

Assume: 1. 3 participating classrooms per school

2. 35 students per class

Per-student Reception Cost is $ 3.83/year

or .026/lesson

or .077/hour

variables--the number of lessons presented per year, H, and the number of students enrolled in a course, N. Each enrolled student would take the 150 lessons of a single year's course. The cost function we are assuming has, then, the following form:

$$TC = a_0 + a_1 H + a_2 N,$$

where a_0, a_1, and a_2 are parameters we can determine from the cost data of the preceding subsection.

The first parameter, a_0, consists of all cost components invariant with respect to hours of programming or student usage, i.e., it consists of central project costs:

$$a_0 = \text{annualized start-up costs} + \text{project administration costs} + (\text{research costs}).$$

We have placed research costs in parentheses because we feel it dubious that these general research costs should be included in the Nicaragua cost function. As most of the research covered by these costs has results directed outside Nicaragua, we will exclude these research costs from our total cost equation; information from Table 26 will allow those who wish to include these costs to do so. (On the other hand, we do include the cost of formative evaluation research as being directly related to program production.) Since we annualized start-up costs at three different discount rates, we have three values for a_0 (each excluding research costs):

$$a_0 = \begin{cases} \$\ 75{,}600/\text{yr} & \text{if } r = 0 \\ \$\ 91{,}800/\text{yr} & \text{if } r = 7.5\% \\ \$112{,}800/\text{yr} & \text{if } r = 15\%. \end{cases}$$

The next parameter, a_1, depends on transmission costs and program production costs; it equals the annualized cost of a lesson plus the cost of transmitting it once. The annualized cost of a lesson is \$107 at a 0 discount rate; \$160 at a 7.5% discount rate; and \$213 at a 15% discount rate. The cost of transmission is \$13.[1] Thus we have

$$a_1 = \begin{cases} \$120/\text{yr} & \text{if } r = 0 \\ \$173/\text{yr} & \text{if } r = 7.5\% \\ \$226/\text{yr} & \text{if } r = 15\%. \end{cases}$$

The final cost parameter, a_2, depends only on the cost per enrolled student per year. From Table 28 we see that a_2 = \$3.83/yr.[2]

Our final cost equations are, then, given by (in dollars per year)

$$TC = \begin{cases} 75{,}600 + 120\ H + 3.8\ N & \text{if } r = 0 \\ 91{,}800 + 173\ H + 3.8\ N & \text{if } r = 7.5\% \\ 112{,}800 + 226\ H + 3.8\ N & \text{if } r = 15\%. \end{cases}$$

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[1] This assumes that each lesson is broadcast only once per year. The relatively small cost of transmission suggests, if there were either pedagogical advantages for repeat broadcasting or advantages to shifting, that the resulting increases in transmission cost would be relatively slight.

[2] Strictly speaking, a_2 = \$3.83 if r = 7.5%; we assume, however, that a_2 is not dependent on r because the cost implications are so slight.

Average Costs

The above equations can be used to compute the average cost of radio per student per year, AC, and the cost per student-hour of exposure, PHC, as a function of the values of H and N. Table 29 shows the results of computations of this sort for two values of H--450 and 900--and several values of N. This table uses the cost function that has a 7.5% discount. Since there are 150 lessons per year, a value of H = 450 implies radio coverage (in mathematics) for 3 grade levels; H = 900 implies radio coverage for all 6 elementary grades.

Even with between 10,000 and 50,000 users the average costs remain substantially above the marginal cost of $3.80 per student per year. And, because of both high marginal costs per student and high programming costs, the costs of the RMP are substantially higher than for other radio projects and fall in the range of instructional television costs.

Discussion

Three basic points emerge from the analysis just presented of the costs of the RMP in Nicaragua:

1. The intensive efforts put into program preparation suggest that, unless careful effort is undertaken to make these programs available to many users, the cost per student of program production will be extremely high. The costs can be spread among users by insuring a long life (10+ years) for the programs, by implementing the RMP through all or most of Nicaragua, and by attempting to use the same programs with only slight revision for Spanish-speaking students in Latin America and the U.S.

Table 29

Average Costs[a]

	H = 450		H = 900	
	AC[b]	PHC[c]	AC	PHC
N				
2,000	89	1.78	128	2.56
10,000	21	.42	29	.58
50,000	7	.14	9	.18
250,000	4.5	.09	4.8	.10

[a] These average costs are computed from the cost function that has a discount rate of 7.5%.

[b] AC stands for the average cost per student per year in dollars.

[c] PHC stands for the per-hour cost of instruction per student; as there are 150 20-minute lessons per year, PHC = AC/50.

2. The presently planned levels of classroom supervision, teacher training, and student worksheet usage result in per student reception costs of $3.80 per year, or, assuming 150 20-minute lessons in a year, cost of 7.7 cents per student-hour. These costs are exceptionally high, suggesting the value of continued, careful experimentation with lower levels of supervision, less frequent and less intensive teacher training, and more limited worksheet use.

3. It appears possible to reduce substantially the reception site costs and to spread programming costs over a large audience. Even if this is done, the project is apt to remain expensive by the standards of instructional radio projects. For this reason, principal emphasis in evaluation of the RMP must be placed on its capacity to improve the effectiveness of instruction, as indicated by its effects on mathematics achievement test scores and student repetition rates. It is too early in the project to assess its performance along these dimensions.

Chapter 8

Other Research Activities

In this chapter we report briefly on three other research activities the project currently has underway. The first is the standardization of a mental arithmetic test developed during the past year at the Institute. The second is the administration of an attitude questionnaire to first-grade teachers in Nicaragua. The third is a study of the determinants of repetition and dropout in Nicaragua.

Standardization of the Primary I Stanford Mental Arithmetic Test

During the past year a set of tests for assessing achievement in mental arithmetic, the Stanford Mental Arithmetic Tests (SMAT), were developed and normed using California elementary school children. This work is described fully in Sachar (1975). Preliminary work on norming the test in Nicaragua was begun in May, 1975.

The SMAT consists of six pairs of tests, two forms for each of Grades 1 through 6. Each test is a domain-referenced test whose content is determined by defining a curriculum and sampling from the curriculum. The Primary tests, for Grades 1, 2, and 3, contain addition, subtraction, and number concepts exercises. Each SMAT test covers exercises ranging from those that all of the students in the appropriate grade level can answer correctly to those that no student can answer correctly, with items presented in order of increasing difficulty. The Primary I test, which is being used in the work in

Nicaragua, contains 100 items, divided into sections of ten items each.

The SMAT tests are administered using a prerecorded tape which contains instructions and test items. All exercises require free responses which are made on a printed answer sheet. The taped test is about 35 minutes long.

Because we were able to devote only a small amount of staff time in Nicaragua to this task, we decided to work this year with only one SMAT test, Primary I, form A. The staff produced and pilot-tested several preliminary versions, resulting in a final version that will be administered later this year to students at six grade levels.

As a first step, the United States (US) version of the test was translated into Spanish by a Nicaraguan staff member and administered to second-grade students in a rural school in Masaya. The children had difficulty following the answer sheet and many did not understand the directions. These children had never taken a standardized test and were not familiar with tape recordings in the classroom.

The instructions were rewritten and the taped introduction was expanded to include more practice in finding the lettered identifiers on the answer sheet. In addition, a 10-minute lesson teaching the five letters used as identifiers was written, to be delivered by the administrator prior to starting the tape recorder. This revision was administered to first- and second-grade students in two rural schools. When it was found to be satisfactory, the lesson on letter identification was incorporated into the taped introduction and the number of sample items was increased from five to ten, to give practice on an entire section, using all exercise identifiers.

These first two test versions were used to establish an adequate introduction to the test. The last and final revision dealt with the problem of translating the exercises. The wording of exercises for the US version of the test was determined by adopting a standard translation from the written form of an exercise to its oral form. For example, 2 + 3 = -- becomes "What is 2 plus 3?," and 2 + -- = 5 becomes "2 plus what equals 5?" Because there was some disagreement among Nicaraguan staff members about the wording of questions, we decided to use this same procedure to determine the spoken Spanish form, that is, to translate from the written mathematical form into the spoken Spanish form. We strove to find the expression that would be most easily understood by the children without explaining how to solve the problem.

Four Nicaraguan staff members (three of them former classroom teachers) participated in the translation process. Although there was initially some disagreement among them, they produced a verbal form for each exercise. Table 30 shows, for each exercise type, the written form, the Spanish form and its English translation (which is not necessarily the same as the English form of the question).

The body of the final Nicaraguan version of the test parallels the US version. Each of the 100 exercises consists of the name of the identifier, the question, and a six-second pause. The questions are arranged in ten 10-item parts with a one and one-half minute break

Table 30

Written and Verbal Forms of SMAT Test Items

Written form	Spanish form	English translation of Spanish form
2 + 3 = ___	Cuanto es dos mas tres?	How much is 2 plus 3?
2 + ___ = 5	Dos mas cuanto es igual a cinco?	2 plus how much is equal to 5?
___ + 3 = 5	Que numero mas tres es igual a cinco?	What number plus 3 is equal to 5?
5 - 3 = ___	Cuanto es cinco menos tres?	How much is 5 minus three?
5 - ___ = 2	Cinco menos cuanto es igual a dos?	5 minus how much is equal to 2?
___ - 3 = 2	Que numero menos tres es igual a dos?	What number minus three is equal to 2?
4 x 2 = ___	Cuanto es cuatro por dos?	How much is 4 times 2?
4 x ___ = 8	Cuatro por cuanto es igual a ocho?	4 times how much is equal to 8?
___ x 2 = 8	Que numero por dos es igual a ocho?	What number times 2 is equal to 8?
6 ÷ 2 = ___	Cuanto es seis entre dos?	How much is 2 into 6?
6 ÷ ___ = 3	Seis dividido entre cuanto es igual a tres?	6 divided by how much is equal to 3?
___ ÷ 2 = 3	Que numero dividido entre dos es igual a tres?	What number divided by 2 is equal to 3?
2/3 = ___/6	A cuantos sextos son iguales dos tercios?	To how many sixths is two-thirds equal?

Table 30, continued

Written form	Spanish form	English translation of Spanish form
1/3 + 1/6 = __	Cuanto es un tercio mas un sexto?	How much is one-third plus one-sixth?
2 6	Cual numero es mayor, el dos o el seis?	Which number is greater, 2 or 6?
7 __	Que numero va despues del siete?	What number goes after 7?
__ 7	Que numero va antes del siete?	What number goes before 7?
7 __ 9	Que numero va entre siete y nueve?	What number goes between 7 and 9?

after parts 4 and 8. As noted above, the introduction of the Nicaraguan version is lengthier and includes ten sample exercises rather than five.

A sampling plan was developed to norm the Spanish SMAT using Masaya public school children in Grades 1 through 6. We decided not to sample the entire country because we learned from the Bureau of Research, in the Ministry of Education, that the phrasing of mathematics problems varies in different parts of the country, in particular, on the eastern and western coasts. All six grades are included to assess achievement levels for children completing primary school, a natural stopping point in their education for a large number of Nicaraguans.

The public schools in Masaya were divided into regional strata, urban, rural, and municipal, as described elsewhere in this report. The test population will consist of approximately 150 students from each grade level, selected from each stratum in proportion to the grade population. In the urban and municipal schools, students from a single grade will be sampled separately. Because of the small number of children in many grades in the rural schools, rural children will be sampled using two grades at a time, 1 and 2, 3 and 4, and 5 and 6, attempting to maintain approximate proportions by grade in the stratum. The test population for each stratum will be formed by sampling classes at random until the required number of students is obtained. In making the calculations we assumed that approximately 60 percent of the children chosen will actually be tested. Each pair of grades will be tested during a one-month period between July 1, 1975 and the end of the school year in November.

Teacher Attitude Study

A questionnaire was developed to investigate those attitudes of teachers that might be influenced by exposure to the radio mathematics program. The instrument was designed to assess attitudes in four areas, the subject matter of mathematics, teaching of mathematics, use of instructional radio, and teaching as a profession.

The questionnaire was administered to teachers in November, 1974, before the initiation of radio lessons, in order to obtain baseline data. It will be used again at the end of the 1975 school year, and then at the beginning and end of each succeeding school year. In addition to providing evidence for attitude changes over time, the data will be used to look for correlations between teacher attitudes, their background characteristics, and the achievement level of their students.

The questionnaire has two types of items. Most items present a statement and ask the teacher to indicate his level of agreement, using a 5-point Likert scale. The remaining items are incomplete sentences that the teacher is asked to complete.

We chose the Likert-scale format because it is direct and easy for teachers to use. However, it is also subject to deliberate bias on the part of the respondent. We felt that the possible bias, while significant in an absolute way, would not affect the value of the questionnaire as a tool for comparative study. The incomplete sentence technique is useful because it gives teachers an opportunity to respond in a less structured way to the themes of the questionnaire. We also pilot-tested items using a semantic differential technique, and concluded that these would not provide additional information.

The questionnaire was given to the 44 teachers whose classes were given the 1974 achievement test. The process of developing the questionnaire, and its contents, will be described in a forthcoming publication that will also discuss the results of the first administration last November.

Determinants of Repetition and Dropout Propensity in Nicaragua

This study is being undertaken by Dean Jamison of Educational Testing Service and Kathleen McNally, of Rutgers University. The study is part of the project's evaluation of the effects of radio instruction on student achievement and is designed to ascertain whether the introduction of radio will have any impact on students' propensity to repeat grades or drop out. Data collection and modelling efforts are now underway for two sets of data on first grade students. The first data set involves 1600 students who were in first grade in the Department of Masaya during the school (and calendar) year 1974, prior to the introduction of radio instruction. The second data set will involve about 800 first grade students from Masaya in 1975; 600 of these 800 will receive their mathematics instruction by the preliminary version of the radio curriculum.

Chapter 9

Plans for 1975-76

The 1975-76 project year encompasses the end of the present academic year and the beginning of the next. School will end in mid-November and commence in mid-February. Our plans for this coming year have changed since the formulation of the initial research plan for the project, in response to our experience in the field. We now plan only a partial revision of the first-grade lessons for next year. With some extension and revision, we will broadcast the lessons that were recorded this year, carrying out the summative evaluation as planned. We will also, as planned, develop lessons for Grade 2. In this Chapter we discuss some of the factors contributing to this change of plans. Then we present a short description of the other project activities that we expect to undertake in the coming year.

We have two reasons for deciding to delay a full curriculum revision until the following year. The first is that the staff does not yet have sufficient training and strength to produce two lessons a day, the number required if we develop second grade and fully revise first grade. The second reason is that it is only now that we feel we are beginning to collect the data we need for a rational revision and to conceptualize the revision process in a useful way. As a result, we do not have the kind of data we need to revise the first grade lessons. The lessons have proved for the most part satisfactory, and are certainly adequate for broadcasting. We will, next academic year, collect the appropriate data to allow for a substantial, data-based revision.

As indicated in the body of this report, the worksheet data, on which we planned to rely as a sole source of information about performance levels during the school year, has turned out to be far more contaminated than we had anticipated. Therefore, we have, within the last month, instituted weekly paper-and-pencil tests in five classrooms. Each test contains 10 items and a matrix sampling design allows us to collect data on 50 items each week. We have established procedures for administering tests that greatly reduce the copying and eliminate help provided by the teacher. We feel that these tests will give us a stronger data base for planning curriculum revision.

In addition, our methods of observing classrooms have changed substantially during the year, and we are not yet satisfied that we have developed the most useful scheme. We plan, during the rest of the school year, to continue to revise the observation form.

For the partial revision of first-grade lessons in preparation for their use during 1976 we plan to do the following.

1. Write five lessons to precede the first radio lesson presented in 1975. These lessons will cover the introductory material teachers were asked to present last year during the first three weeks of school. We anticipate using these lessons during the first full week of school.

2. Write the missing lessons (two each week for the first four weeks) that the staff was unable to produce last year.

3. Write ten lessons to be presented after the last 1975 lesson, thereby extending the instructional material by two weeks. The time for these lessons will come from the two weeks saved at the beginning of the school year.

4. Rewrite five to ten lessons that the staff this year found unsuccessful.

The first-grade radio lessons will be used in approximately 45 classrooms. The children in all of these classrooms will be pre- and posttested. Thirty of the classrooms will be randomly selected from among schools that were not used for experimental purposes this year. These 30 classrooms will receive the experimental treatment which, in addition to pre- and posttesting, consists of teacher training and the provision of materials and radio lessons. These classes will not be observed nor will the children be given interim tests. Five additional classes will be chosen (randomly) for observation and testing purposes. In addition, we plan to give the 17 teachers who participated in this year's experimental work the option of using radio lessons in their classrooms. We anticipate that approximately 10 of them will do so, bringing the number of classrooms to about 45. Twenty control classes will be selected randomly, and will be pre- and posttested.

We plan to choose 9 experimental second grade classes to participate in the pilot-testing phase of curriculum development, three each from rural, municipal, and urban settings. Roughly half of these will be classes that have substantial numbers of children who received radio lessons in first grade. Because of the mobility of students and the high repetition rate, we cannot expect second-grade students to have used radio lessons, even with more widespread use of the program, and we plan to write second grade lessons so they will be suitable for both experienced and inexperienced children. The experimental classes will be observed and tested according to a schedule similar to that in use at present.

We plan to continue developing and administering tests. The full testing schedule for 1975-76 includes the following.

Date	Test administered
July - October, 1975	Mental arithmetic test
November, 1975	First grade year-end test 16 experimental classes 9 non-radio classes (pretested)
	Second grade year-end test 16 randomly selected second grade classes
February, 1976	TOBE pretest 45 radio classes 20 control classes
	Second grade entry-level skills 9 experimental classes 9 non-radio classes

The second grade year-end test will be written by the project staff and is designed to provide information about the achievement level of traditional second grade classes, to aid in curriculum development.

We have proposed to the Ministry of Education that for 1976 they increase the level of support to the project. For 1975, the Ministry supports 11 staff positions, 7 of them professional. For 1976 we are asking for support for 24 positions, 15 of them in the professional category. Thus, we are asking the Ministry to support our present staff. We plan to continue recruiting for all professional positions, and consider hiring and training more script writers to have the highest priority.

Two staff members have applied for (and will probably receive) fellowships to attend an eight-month OAS training course in writing and producing instructional programs for TV and radio. The course also provides some training in techniques of evaluation. The first five months of instruction are at the Centro Multinacional de Tecnologia Educativa in Mexico, the remainder at a similar center in either Brazil, Chile, or Colombia.

We are limited in the opportunity to provide training for staff members at Stanford because almost none of the Nicaraguan staff members speak English. We plan to bring Mrs. Vrooman, who speaks fluent English, to Stanford for some portion of the next project year.

The project is becoming well-known in Nicaragua and has received several visitors through the Ministry of Education, from Nicaragua as well as from other Latin American countries. We feel we are well established and look forward to productive second year in Masaya.

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APPENDIX A

Data Tables

Table I

Content of Pilot Lesson Segments

Lesson & segment	Strand	Presentation mode[a]	Description
L1-1	NUM	O	Mando-mando game
L1-2	NUM	O	Counting aloud
L1-3	NUM	O	Counting sounds
L1-4	NUM	W	Number dictation
L1-5	NUM	O	Successors
L1-6 b	APL	O	Days of the week
L1-7 P	GEO	O	Comparing lengths
L1-8 P	NUM	O	Mando-mando game
L2-1	NUM	O	Mando-mando game
L2-2	NUM	O	Counting aloud
L2-3	APL	O	Comparing lengths
L2-4	BAS	W	Identifying common objects
L2-5	NUM	W	Number dictation
L2-6	NUM	O	Successors
L2-7	BAS	W	Identifying common objects
L2-8 P	APL	W	Measuring with rulers
L3-1	NUM	O	Mando-mando game
L3-2	NUM	O	Counting aloud
L3-3	NUM	O	Counting sounds
L3-4	BAS	W	Identifying common objects
L3-5	NUM	O	Successors
L3-6	NUM	W	Successors
L3-7	GEO	W	Circling longest, shortest
L3-8 P	APL	W	Measuring with rulers
L4-1	NUM	O	Mando-mando game
L4-2	GEO	W	Circling longest, shortest
L4-3	NUM	O	Successors
L4-4	NUM	W	Successors
L4-5	BAS	W	Identifying common objects
L4-6	GEO	W	Drawing longer, shorter lines
L4-7 P	APL	W	Measuring with rulers
L4-8 P	APL	O	Comparing lengths

Table I, cont.

Lesson & segment	Strand	Presentation mode	Description
L5-1	NUM	0	Mando-mando game
L5-2	NUM	0	Counting aloud
L5-3	APL	0	Comparing coins
L5-4	APL	W	Identifying coins
L5-5	ADD	0	Story problems--addition
L5-6	ADD	0	Mental arithmetic
L5-7	ADD	W	Mental arithmetic
L5-8 P	APL	W	Measuring with rulers
L5-9 P	APL	W	Drawing lines of given length
L6-1	NUM	0	Counting aloud
L6-2	ADD	0	Mental arithmetic
L6-3	ADD	W	Mental arithmetic
L6-4	APL	W	Comparing coins
L6-5	APL	0	Comparing coins
L6-6	APL	W	Story problems--money
L6-7 P	APL	W	Giving value of coins

[a] W = written, 0 = oral.

[b] P means presented after the taped lesson (postbroadcast).

Table II

Pilot Test Results by Item

Item Identifier[a]	Strand[b]	n	Percentage Correct
A1	NUM	91	94.5
A2	NUM	91	93.4
A3	NUM	91	63.7
A4	NUM	91	39.6
A5	SUB	91	52.7
A6	APL	91	75.8
A7	ADD	91	54.9
A8	SUB	91	24.2
A9	ADD	91	58.2
A10	SUB	91	27.5
B1-1	NUM	41	87.8
B1-2	NUM	41	46.3
B1-3	NUM	41	39.0
B1-4	ADD	41	43.9
B1-5	DIV	41	22.0
B1-6	APL	41	14.6
B1-7	APL	41	63.4
B1-8	NUM	41	65.9
B1-9	APL	41	41.5
B1-10	NUM	41	17.1
B2-1	GEO	50	92.0
B2-2	NUM	50	86.0
B2-3	NUM	50	72.0
B2-4	NUM	50	50.0
B2-5	NUM	50	22.0
B2-6	APL	50	20.0
B2-7	NUM	50	52.0
B2-8	NUM	50	78.0
B2-9	APL	50	84.0
B2-10	NUM	50	58.0
C1-1	NUM	17	64.7
C1-2	APL	17	5.9
C1-3	ADD	17	23.5
C1-4	ADD	17	35.3
C1-5	MUL	17	35.3
C1-6	MUL	17	29.4
C1-7	GEO	17	11.8
C1-8	SUB	17	11.8
C1-9	ADD	17	0.0
C1-10	SUB	17	11.8

Table II, cont.

Item Identifier	Strand	n	Percentage Correct
C2-1	NUM	18	5.6
C2-2	GEO	18	44.4
C2-3	ADD	18	50.0
C2-4	SUB	18	27.8
C2-5	SUB	18	22.2
C2-6	DIV	18	0.0
C2-7	SUB	18	22.2
C2-8	ADD	18	5.6
C2-9	MUL	18	22.2
C2-10	ADD	18	0.0
C3-1	NUM	18	11.1
C3-2	APL	18	27.8
C3-3	NUM	18	66.7
C3-4	SUB	18	16.7
C3-5	MUL	18	38.9
C3-6	MUL	18	22.2
C3-7	NUM	18	16.7
C3-8	MUL	18	5.6
C3-9	NUM	18	5.6
C3-10	SUB	18	0.0
C4-1	NUM	20	45.0
C4-2	APL	20	5.0
C4-3	NUM	20	70.0
C4-4	SUB	20	50.0
C4-5	SUB	20	30.0
C4-6	DIV	20	20.0
C4-7	DIV	20	0.0
C4-8	SUB	20	5.0
C4-9	SUB	20	0.0
C4-10	SUB	20	0.0
C5-1	NUM	18	33.3
C5-2	APL	18	22.2
C5-3	ADD	18	55.5
C5-4	SUB	18	33.3
C5-5	MUL	18	22.2
C5-6	MUL	18	11.1

Table II, cont.

Item Identifier	Strand	n	Percentage Correct
C5-7	ADD	18	50.0
C5-8	ADD	18	22.2
C5-9	ADD	18	5.6
C5-10	ADD	18	5.6

[a] Test items came from forms A, B1, B2, C1, C2, C3, C4, and C5. Items are numbered consecutively within each form.

[b] Strand abbreviations are

- NUM Number concepts
- ADD Addition
- SUB Subtraction
- GEO Geometry
- MUL Multiplication
- DIV Division
- APL Applications

Table III

Achievement Test Results by Item

Item Identifier	Strand	n	Percentage Correct
A1	NUM	1241	80.82
A2	NUM	1241	71.64
A3	NUM	1241	41.98
A4	NUM	1241	76.87
A5	NUM	1241	79.37
A6	SUB	1241	49.80
A7	ADD	1241	50.52
B1-1	NUM	246	91.46
B1-2	ADD	246	45.93
B1-3	APL	246	65.85
B1-4	NUM	245	55.10
B1-5	GEO	245	96.33
B1-6	NUM	245	27.76
B1-7	SUB	245	25.71
B2-1	NUM	265	87.55
B2-2	SUB	265	60.00
B2-3	APL	265	70.19
B2-4	NUM	265	40.00
B2-5	GEO	265	98.87
B2-6	NUM	265	79.25
B2-7	SUB	265	23.77
B3-1	NUM	223	84.75
B3-2	ADD	223	67.71
B3-3	APL	223	71.30
B3-4	NUM	220	80.45
B3-5	GEO	223	95.96
B3-6	NUM	223	38.12
B3-7	SUB	223	7.62
B4-1	NUM	240	73.75
B4-2	SUB	240	43.33
B4-3	APL	240	49.58
B4-4	NUM	239	82.85
B4-5	GEO	240	80.83
B4-6	NUM	240	41.25
B4-7	SUB	239	25.10
B5-1	NUM	267	66.67

Table III, cont.

Item Identifier	Strand	n	Percentage Correct
B5-2	ADD	267	50.94
B5-3	APL	267	52.43
B5-4	NUM	266	37.59
B5-5	GEO	267	73.03
B5-6	NUM	263	64.26
B5-7	MUL	267	26.22
C1-1	NUM	248	41.94
C1-2	APL	248	31.05
C1-3	NUM	248	47.98
C1-4	APL	248	37.50
C1-5	ADD	248	60.48
C1-6	SUB	248	35.48
C1-7	MUL	248	25.00
C2-1	NUM	255	18.43
C2-2	APL	255	36.08
C2-3	NUM	255	56.47
C2-4	APL	255	38.82
C2-5	ADD	255	47.45
C2-6	SUB	255	28.24
C2-7	ADD	255	11.76
C3-1	NUM	243	16.46
C3-2	APL	243	5.35
C3-3	NUM	243	60.08
C3-4	APL	243	2.88
C3-5	ADD	243	27.57
C3-6	MUL	243	43.62
C3-3	SUB	243	35.80
C4-1	NUM	246	49.59
C4-2	APL	246	40.24
C4-3	NUM	246	47.97
C4-4	APL	246	56.10
C4-5	ADD	246	47.97
C4-6	ADD	246	41.87
C4-7	SUB	246	31.71
C5-1	NUM	249	20.88
C5-2	APL	249	35.74
C5-3	NUM	249	36.14
C5-4	APL	249	8.84
C5-5	ADD	249	47.39
C5-6	MUL	249	38.55
C5-7	SUB	249	21.69

Table IV

Class Means Using Total Scores Estimated

by Kleinke Procedure

Class	Region[a]	n	Mean	Standard Deviation
1	U	31	42.42	11.23
2	U	37	44.32	9.33
3	U	36	38.81	12.05
4	U	28	41.29	11.93
5	U	31	32.42	12.41
6	U	31	31.94	11.46
7	U	27	34.07	11.99
8	M	33	30.79	12.75
9	M	27	35.19	14.05
10	R	22	33.32	11.45
11	U	32	36.88	12.74
12	M	27	44.44	11.08
13	M	28	42.00	10.74
14	U	27	32.04	13.19
15	R	13	23.46	10.13
16	R	34	30.53	13.64
17	U	21	35.24	12.25
18	R	29	38.07	12.17
19	R	19	24.16	10.40
20	M	41	33.95	12.40
21	R	16	33.75	9.95
22	R	38	37.26	14.17
23	M	24	30.50	12.21
24	M	28	44.18	12.27
25	M	45	38.56	12.51
26	M	33	28.70	10.35
27	R	22	40.59	11.18
28	M	24	37.71	11.25
29	R	41	36.34	11.00
30	R	29	35.45	11.71
31	U	22	41.46	11.64
32	U	33	40.42	10.08
33	U	14	44.00	10.47
34	U	30	40.07	13.62
35	R	36	41.19	12.43
36	M[b]	21	33.52	11.82
37	U-Radio	25	37.48	12.64
38	R-Radio	25	41.08	11.72
39	M-Radio	24	38.00	11.85

Table IV, cont.

Class	Region[a]	n	Mean	Standard Deviation
40	R-Radio	32	43.25	10.62
41	U-Radio	29	47.24	11.39
42	M-Radio	22	30.50	10.09
43	U	35	34.29	12.62
44	R	19	41.68	13.74

Note. Classes 1-30 were selected randomly.

[a] U = urban, M = municipal, R = rural.

[b] "Radio" classes were used to try out pilot lessons.

APPENDIX B

First-Grade Achievement Test, 1974[a]

Question number	Item identifier	Printed component	Oral component
1	A1	13 cats, 7 white and 6 black	"Count the white cats."
2	A2	2 bags of caramels, one containing 17 caramels, the other containing 15	"Circle the bag that has the fewest caramels."
3	B1-1	Blank line	"Write the number 7"
	B2-1	"	40
	B3-1	"	15
	B4-1	"	200
	B5-1	"	53
4	B1-2	Blank line	"How much is 8 + 4?"
	B2-2	"	6 - 3?
	B3-2	"	5 + 1?
	B4-2	"	28 - 2?
	B5-2	"	20 + 7?
5	C1-1	30 40 50 __ __	"Read the numbers carefully. Write the numbers that are missing."
	C2-1	2 4 6 __ __	
	C3-1	5 10 15 __ __	
	C4-1	72 73 74 __ __	
	C5-1	8 7 6 __ __	
6	A3	2 coins--50 cents and 5 cents. Multiple choice--50, 55, 45 cents.	"Circle the number that tells how much the two coins together are worth."
7	B1-3	Blank line	"Maria had 3 hair ribbons. Her mother gave her 2 more. Write the number of ribbons that Maria has now."
	B2-3	"	"Martha gave 3 bananas to the teacher. Jose gave her 2 and Miguel 2. Write the number of bananas that the teacher received."

[a] Translated from Spanish

Question number	Item identifier	Printed component	Oral component
7	B3-3	Blank line	"Manuel had 4 buttons to play with. Playing with another boy he lost 3. Write the number of buttons he has left."
	B4-3	"	"I have 2 boxes. In each box there are 4 dolls. Write the number of dolls that I have."
	B5-3	"	"Mama has 6 hens. She divides them between her two children. Write the number of hens she gives to each child."
8	B1-4		"Circle the figure that is divided into halves."
	B2-4		"Circle the figure that is divided into halves."
	B3-4		"Circle the figure that is divided into fourths."
	B4-4		"Circle the figure that is divided into halves."
	B5-4		"Circle the figure that is divided into thirds."
9	C1-2	Juan had 5 mangos. He ate 2. How many mangos does he have now? 3 10 7	"Read this problem carefully. Circle the correct answer."

Question number	Item identifier	Printed component	Oral component
9	C2-2	Nina bought 6 oranges. Her mama gave her 1 more. How many oranges does Nina have now? 6 7 5	"Read this problem carefully. Circle the correct answer."
	C3-2	Maria has 6 caramels. Pedro has 5. Maria has more. How many more? 11 3 1	"
	C4-2	Dora has 4 dahlias and 2 roses. How many flowers does Dora have? 2 6 8	"
	C5-2	Eva has 3 toys. Manolo has 3 others. How many toys do they have between the two of them? 6 9 3	"
10	C1-3	80 73 91	"Circle the smallest number."
	C2-3	52 57 59	
	C3-3	4 3 5	
	C4-3	284 247 231	
	C5-3	63 51 47	

Question number	Item identifier	Printed component	Oral component
11	B1-5	House and 4 dogs	"Circle the dog that is closest to the house."
	B2-5	3 ladders of different sizes	"Circle the longest ladder."
	B3-5	3 trees of different sizes	"Circle the smallest tree."
	B4-5	Nest with 4 birds flying around it	"Circle the bird that is flying above the nest."
	B5-5	2 glasses	"Circle the glass that is on the right."
12	B1-6	Blank line	"Write the number that comes before 30."
	B2-6	"	...after 29.
	B3-6	"	...before 58.
	B4-6	"	...before 46.
	B5-6	"	...before 8.
13	A4	5 boys waiting in line to buy tickets to the circus.	"Circle the third boy in line."
14	A5	FIFTY FIFTEEN FOURTEEN FOUR	"Circle the word 'fourteen'."

Question number	Item identifier	Printed component	Oral component
15	C1-4	clock showing 6:00	"Write the hour the clock says."
	C2-4	... 4:00	"
	C3-4	... 10:30	"
	C4-4	... 12:00	"
	C5-4	... 2:30	"
16	C1-5	4 + 3	"Read each exercise carefully and write the correct answer."
	C2-5	24 21 + 41	
	C3-5	30 + 4	
	C4-5	6 + 10 = __	
	C5-5	9 + 5	
17	A6	5 - 3 = __	
18	A7	160 + 530	

Question number	Item identifier	Printed component	Oral component
19	C1-6	6 - 0 = __	"Read each exercise carefully and write the correct answer."
	C2-6	13 - 8 = __	
	C3-6	2 x 5 = __	
	C4-6	3 + 0 = __	
	C5-6	5 x 1	
20	C1-7	9 x 10 = __	
	C2-7	38 + 55	
	C3-7	84 - 21	
	C4-7	72 - 1 = __	
	C5-7	10 - 7	
21	B1-7	90 - 10	
	B2-7	94 - 3	
	B3-7	42 - 5	
	B4-7	6 - 3 = __	
	B5-7	32 x 3	

APPENDIX C

Adaptation of Kleinke Procedure for Estimating Student Scores

Matrix sampling has been demonstrated to be a useful method for establishing national test norms (Lord, 1962). Sampling both examinees and items serves to reduce the amount of testing time required of each examinee. Analysis of resultant test data is based on the assumption that the sample of items and the sample of examinees are drawn independently and that responses to an item do not depend on the context in which the item is presented.

Although each examinee receives only a portion of the items on the total test, various investigators have attempted to estimate parameters of the total test distribution of all examinees. Most studies consist primarily of estimates of total-test mean and variance (Owens and Stufflebeam, 1969; Plumlee, 1964). Four studies have included estimates of the total-test distribution (Cook and Stufflebeam, 1967; Lord, 1962; Kleinke, 1972; Bunda, 1973). Lord and Cook and Stufflebeam fitted a negative hypergeometric distribution to three parameters--an estimated mean, an estimated variance, and the number of items on the total test.

With the exception of Kleinke and Bunda, none of the authors estimates total scores for individuals who were administered partial tests. Bunda estimated total scores from overlapping item samples using a regression equation whose coefficients are found from the item means and the item variance-covariance matrix. The vector of regression weights, b(T,i), for any particular sample is

$$b(T,i) = s(i,j)^{-1} \; s(T,i)$$

where $s(i,j)^{-1}$ is the ij-th element of the inverse of the inter-item variance-covariance matrix, and s(T,i) is the vector of item-total covariances.

Kleinke offered a method for nonoverlapping item samples using a linear prediction approach for generating the estimated total-test distribution. With this approach, the total-test may be considered a composite of two tests, X, consisting of the items presented to the student, and Y, the items not presented to the student. The observed score on X is used to predict the score on Y. The predicted total-test score is then the sum of scores on X and Y.

The 1974 achievement test had three parts, A, B, and C, (which, in the context of the present discussion can be thought of as three separate tests). For each student, the total predicted score is the sum of one observed score (for Part A) and two predicted scores (for Parts B and C). The maximum score for Part A is 7, that for Parts B and C, 35, yielding a total maximum score of 77. Let

T(A) be the observed score on Part A,

T(B) be the predicted score on Part B, and

T(C) be the predicted score on Part C.

Then the total score, T, is the sum of these three,

$$T = T(A) + T(B) + T(C).$$

Kleinke's method was used to estimate scores for Parts B and C. To obtain T(j), j = B or C, let

X be the score on the form the student took,

$\bar{X}$ be the mean score on this form,

Sx be the standard deviation on this form,

$\bar{Y}t$ be the sum of the means of the other 4 forms, taken as an estimate of the mean of a composite consisting of the other forms,

St be the square root of the sum of the 4 variances, taken as an estimate of the standard deviation of the other forms, and

Y′ be the total predicted score for the other forms.

Then a student's estimated score on Part j is shown in Equation (1).

$$T(j) = X + Y' = X + \bar{Y}t + \frac{St}{Sx}(X - \bar{X}) \qquad (1)$$

Equation (1) is obtained from the regression equation for X and Y,

$$Y' = \bar{Y} + r\frac{SY}{SX}(X - \bar{X}),$$

where r is the correlation between X and Y. If we assume perfect correlation between X and Y (r = 1) we obtain Equation (1). If we assume no correlation between X and Y (r = 0), then $Y' = \bar{Y}$, and

$$T(j) = X + \bar{Y} \quad (2)$$

These two equations yield upper and lower bounds for predicted scores, depending on the value of r and on the sign of $(X - \bar{X})$. (If $X - \bar{X} > 0$ then Equation (1) is the upper bound and Equation (2) the lower bound.)

The means and standard deviations obtained for predicted total-test scores (T) for the 1974 achievement test, calculated using Equations (1) and (2) are shown in the table below.

Table

Means and Standard Deviations for Predicted Total-test Scores

	Equation 1	Equation 2
Mean	37.61	37.61
S.D.	125.17	23.97

The small variance resulting from the application of equation 2 reflects the use of only mean scores in the composition of the total-test score.

APPENDIX D

Terminal Curriculum Objectives for First Grade

Two types of objectives are identified, minimal and advanced. Minimal objectives are to be attained by all students, advanced objectives guide curriculum development of topics beyond the minimal level. Some objectives guide curriculum development but are not testable with the group pencil-and-paper testing procedures used by the project to evaluate achievement.

The following list identifies objectives as minimal (M) or advanced (A) and as amenable to test using our procedures (T) or not (N). Objectives are identified by strand. The objectives are described starting on page 4. In describing addition and subtraction exercises, lower case letters are used to represent single digits.

Strand	Description	Minimal or Advanced	Testable
NUM-1	Rote counting by ones	M	N
NUM-2	Rote counting by twos	A	N
NUM-3	Rote counting by fives	A	N
NUM-4	Rote counting by tens	M	N
NUM-5	Rote counting backwards	A	N
NUM-6	Reading numerals	M	N
NUM-7	Selection of numeral	M	T

Strand	Description	Minimal or Advanced	Testable
NUM-8	Writing numerals	M	T
NUM-9	Successors, oral stimulus	M	T
NUM-10	Successors, printed stimulus	M	T
NUM-11	Predecessors, oral stimulus	A	T
NUM-12	Predecessors, printed stimulus	A	T
NUM-13	Counting	M	T
NUM-14	Counting a specified subset	A	T
NUM-15	Counting the complement of a specified set	A	T
NUM-16	Greatest and least	M	T
NUM-17	Completing sequences	A	T
NUM-18	Ordinals	M	T
NUM-19	Reading number words	A	T
NUM-20	Selecting number words	A	T
NUM-21	Writing number words	A	T
NUM-22	Fractions, identification	M	T
NUM-23	Fractions, discrimination	M	T
ADD-1	Addition, oral stimulus	M	T
ADD-2	Vertical addition	M	T
ADD-3	Horizontal addition	M	T
ADD-4	Horizontal addition, noncanonical format	A	T
SUB-1	Subtraction, oral stimulus	M	T
SUB-2	Vertical subtraction	M	T

Strand	Description	Minimal or Advanced	Testable
SUB-3	Horizontal subtraction	M	T
MEA-1	Length, cm.	M	T
APL-1	Money, identification	M	T
APL-2	Money, value	M	T
APL-3	Time, hours	A	T
APL-4	Time, days of week	A	N
APL-5	Time, successors of days of week	A	N
APL-6	Word problems, addition	M	T
APL-7	Word problems, subtraction	M	T
APL-8	Word problems, multiplication	A	T
APL-9	Word problems, division	A	T

Objectives For First Grade

NUM-1 Rote counting by ones

When asked to count aloud, the child will count, "one, two, three,..." until stopped (no farther than 100).

NUM-2 Rote counting by twos

When asked to count aloud by twos, the child will count, "two, four, six,..." until stopped (no farther than 20).

NUM-3 Rote counting by fives

When asked to count aloud by fives, the child will count, "five, ten, fifteen,..." until stopped (no farther than 50).

NUM-4 Rote counting by tens

When asked to count aloud by tens, the child will count, "ten, twenty, thirty,..." until stopped (no farther than 100).

NUM-5 Rote counting backwards

When asked to count backwards from ten the child will count, "ten, nine, eight,...,one."

NUM-6 Reading numerals

Given a printed numeral (0 to 100) the child will say aloud the name of the number.

Example: "What number is this?"

NUM-7 Selection of numeral

Given a set of 2 to 10 printed numerals (0 to 100) and the oral instruction to select a specified numeral the child will indicate the correct numeral by pointing or circling.

Example: "Circle the 41"

58 0 4 41 40 14

NUM-8 Writing numerals

Given an oral instruction to write a specified numeral (0 to 99) the child will do so.

Example: "Write the number 87."

NUM-9 Successors, oral stimulus

When asked to produce the number that follows a specified number (1 to 98) the child will give the correct response orally or as a numeral.

Example: "What number comes after 32?"

Example: "Write the number that comes after 59."

NUM-10 Successors, printed stimulus

Given a printed numeral (1 to 98) and the oral instruction to write the successor the child will do so.

Example: "Write the number that comes after this one."

35 _

NUM-11 Predecessors, oral stimulus

When asked to produce the number that comes before a specified number (2 to 99) the child will give the correct response orally or as a numeral.

Example: "What number comes before 20?"

Example: "Write the number that comes before 8."

NUM-12 Predecessors, printed stimulus

Given a printed numeral (2 to 99) and the oral instruction to write the predecessor the child will do so.

Example: "Write the number that comes before this one."

_ 15

NUM-13 Counting

Given a set of up to 50 small similar objects (such as pencils, beans, or bottle tops), or a drawing of a set of similar objects (such as balloons, cows, or cars), and an oral instruction to count, the child will say or write the number of objects in the set.

Example: "Count the baseballs."

(appropriate picture)

NUM-14 Counting a specified subset

Given a set (or a picture of a set) of up to 50 similar objects containing a subset of up to 10 objects distinguished from its complement by a characteristic that can be recognized by the child, and an oral instruction to count the object with the distinguishing characteristic, the child will say or write the number of objects in the subset.

Example: "Count the marbles that have spots."

(appropriate picture)

NUM-15 Counting the complement of a specified set

Given a set (or a picture of a set) of up to 50 similar objects containing a subset of objects distinguished from its complement by a characteristic that can be recognized by the child, with the complement of the subset containing no more than 10 objects, and the oral instruction to count the objects that do not have the distinguishing characteristic, the child will say or write the number of objects in the complement of the subset.

Example: "Count the clowns that do not have hats."

(appropriate picture)

NUM-16 Greatest and least

Given a set of 2 to 5 printed numerals (0 to 100), and the oral instruction to select the greatest (or least), the child will indicate the correct choice by pointing or circling.

Example: "Point to the least number."

25 2 52 11

NUM-17 Completing sequences

Given a printed arithmetic sequence of 4 to 8 numbers, with the characteristics described below, and with any number other than the first replaced by a blank line, the child will write the missing number.

Incremental difference	Starting number of form (k an integer)	Limits on numbers
1	k	1 - 100
2	2k	2 - 20
5	5k	5 - 50
10	10k	10 - 100
-1	k	10 - 1

Example: "Write the missing number."

4 6 __ 10

NUM-18 Ordinals

Given an ordered set (or picture of an ordered set) in which there is an unambiguous first element and ordering (i.e., the child can identify the first element, the next, etc.), and an oral instruction to select the second, third, fourth, fifth, or sixth object, the child will indicated the correct answer by pointing or circling.

Example: "Circle the fifth person in line."

(appropriate picture)

NUM-19 Reading number words

Given a printed name for a number from one to ten the child can read the word aloud.

NUM-20 Selecting number words

Given a set of number names (1 to 10) and an oral instruction to select a specified word, the child will indicate the correct choice by pointing or circling.

Example: "Circle the word five."

ONE FIVE FOUR THREE

NUM-21 Writing number words

Given the oral instruction to write the word for a specified number between one and ten the child can do so.

Example: "Write with letters the word eight."

NUM-22 Fractions, identification

Given a set of figures divided into 2, 3, 4, or 5 equal parts, the child will indicate by circling or pointing the figure that is divided into halves, thirds, or fourths. (Figures are divided by horizontal or vertical lines and all parts are of equal size and shape.)

Example: "Circle the figure that is divided into thirds."

(appropriate picture)

NUM-23 Fractions, discrimination

Given a pair of figures one of which is divided into 2 (3,4) equal parts and the other into 2 (3,4) unequal parts, the child will select the one that is divided into halves (thirds, fourths).

Example: "Circle the figure that is divided into thirds."

ADD-1 Addition, oral stimulus

Given an addition exercise presented orally, of the specifications described below, the child will produce the sum orally or as a printed numeral. (Recall that lower case letters represent single digits, e.g. a0 is a multiple of 10 less than 100, etc.)

Exercise description	Example
a + b	"Write the sum of 6 and 7."
a0 + b	"What is 20 plus 8?"
ab + 1	"What is 28 plus 1?"
a + b + c, a + b <= 10	"What is 4 plus 5 plus 8?"

ADD-2 Vertical addition

The child will write the correct answer for an addition exercise presented in vertical format for any of the following classes of exercises.

Exercise description		Example
a + b		6 + 3
ab + c	b + c <= 9	23 + 5
ab +cd	a + c <= 9 b + d <= 9	17 +62
a b + c	a + b <= 10	2 5 + 3

ADD-3 Horizontal addition

The child will write the correct answer to an addition exercise presented in horizontal format for any of the following classes of exercises.

Exercise description	Example
a + b = ___	5 + 9 = __
a0 + b = ___	70 + 2 = __
ab + 1 = ___	36 + 1 = __
a + b + c = ___, a + b <= 10	7 + 2 + 5 = __

ADD-4 Horizontal addition, noncanonical format

Given a written exercise of the form

a + __ = b or __ + a = b

and the oral instruction to supply the missing number the child will write the missing addend.

Example: "Write the missing number."

6 + __ = 9

SUB-1 Subtraction, oral stimulus

Given a subtraction exercise presented orally, of the specifications described below, the child will produce the correct answer orally or as a printed numeral.

Exercise description	Example
a - b	"How much is 7 minus 3?"
ab - b	"Write the difference, 23 minus 3."
ab - 1	"How much is 25 minus 1?"

SUB-2 Vertical subtraction

The child will write the correct answer for a subtraction exercise presented in vertical format for any of the following classes of exercises.

Exercise description		Example
$\begin{array}{r} a \\ \underline{-\ b} \end{array}$		$\begin{array}{r} 4 \\ \underline{-\ 3} \end{array}$
$\begin{array}{r} ab \\ \underline{-\ c} \end{array}$	$b >= c$	$\begin{array}{r} 26 \\ \underline{-\ 6} \end{array}$
$\begin{array}{r} ab \\ \underline{-cd} \end{array}$	$b >= d$ $a >= c$	$\begin{array}{r} 65 \\ \underline{-22} \end{array}$

SUB-3 Horizontal subtraction

The child will write the correct answer to a subtraction exercise presented in horizontal format for the following exercise class.

Exercise description	Example
a - b = ___	9 - 2 = __

MEA-1 Length, cm

Given a ruler marked in centimeters and an object that is 1 cm, 2 cm,..., or 10 cm, in length, the child will measure and give orally or as a numeral the correct length.

APL-1 Money, identification

Given a set (or picture of a set) of up to 4 coins or bills (of no greater value than 100 cordobas), and the oral instruction to choose the coin (bill) of a specified value, the child will indicate the correct response by pointing or circling.

APL-2 Money, value

Given a set of coins or bills conforming to the specifications given below, the child will write the combined value as a numeral.

For bills, sums are of the form A + B, D + B, and A + B + C where A, B, C are chosen from the set :1, 2, 5 cordobas: and D is chosen from the set :10, 20, 50 cordobas:

for coins, sums are of the form A + B and C + A, where A, B are chosen from the set :5, 10 centavos: and C is 50 centavos.

APL-3 Time, hours

Given pictures of three clocks showing time to an even hour, and an oral instruction to select the clock that shows a specified time, the child will indicate the correct choice by pointing or circling.

APL-4 Time, days of the week

When asked to recite the days of the week the child will respond, "Monday, Tuesday,...Sunday."

APL-5 Time, successors of days of the week

When asked for the day that follows a specified day, the child will give the correct response orally.

APL-6,7,8,9 Word problems

Not written yet.

APPENDIX E

Materials for Lesson 18

This appendix contains the following materials for Lesson 18 in the order given here.

Curriculum Outline

A description of the mathematical contents of the lesson

Notes to Script Writers

Directions to the script writers about specific wording of instructional material

Student Worksheet

Radio Script

Script as prepared for recording artists

Teachers' Guide

Guide to the postbroadcast activities

Lección 18 Versión 1 Fecha 28/2/75.- Primer Grado

Materiales: HT #18, tarjetas (1 a 9)

Seg.	Tema y Nivel		Presentación	Parte H. T.	Respuesta Tipo	Respuesta Tiempo	Título y/o Ejemplo
1	SUM	3.1	Radio		Oral física	2 seg. 5 seg.	Aprestamiento para la adición, con dedos. "¿Cuánto es 2 más 2 (3+2, 4+1, 1+2). Probémoslo con dedos."
2	NUM	34.3	Radio		Oral		Conteo de rutina, 1 a 20. (2 veces)
3	NUM	35.2	Radio		Oral		Sucesores, 1 a 10, oral "¿Qué número va después del 5 (8,7,9,10)"?
4	NUM	44.1	Radio/HT	1	num	8 seg.	Escribir numerales, 1 a 6, al dictado. "Escriban el número 4 (3,5,2,6)."
5	NUM	45.1	Radio/HT	2	Oral num	2 seg. 8 seg.	Sucesores, 1 a 4, respuesta escrita. "¿Qué número va después del 2 (1,4,3,1)? Bien. Escriban el número que va después del 2."
6	NUM	39.2	Radio/HT	4	SM	5 seg.	Ordinales, 1o. y 2o. , con dibujos. "Hay un plato en la primera mesa. ¿Qué hay en la segunda mesa? Encierren la primera mesa." (primera mesa, segunda canasta, segunda caja, primer plato)
7	SUM	2.1	Radio/HT	3	dib. oral	12 seg. 2 seg.	Aprestamiento para la adición, dibujando. "Dibujen 2 rueditas en la primera línea. Dibujen 1 ruedita en la segunda línea. ¿Cuántas hay por todo?" (También: 1 + 3, 3 + 2, 2 + 2)
8	NUM	46.1	Maestro/HT	5	SM		Leer numerales, 1 a 7, SM "Encierren el 3 (6,2,4,7,5)."
9	NUM	40.3	Maestro/tarjetas		Oral		Leer numerales, 1 a 9, con tarjetas.
10	NUM	41.3	Maestro/mat. concreto		Oral física		Conteo cardinal, 1 a 10, con material concreto.

Lección 18

Notas al escritor de libretos

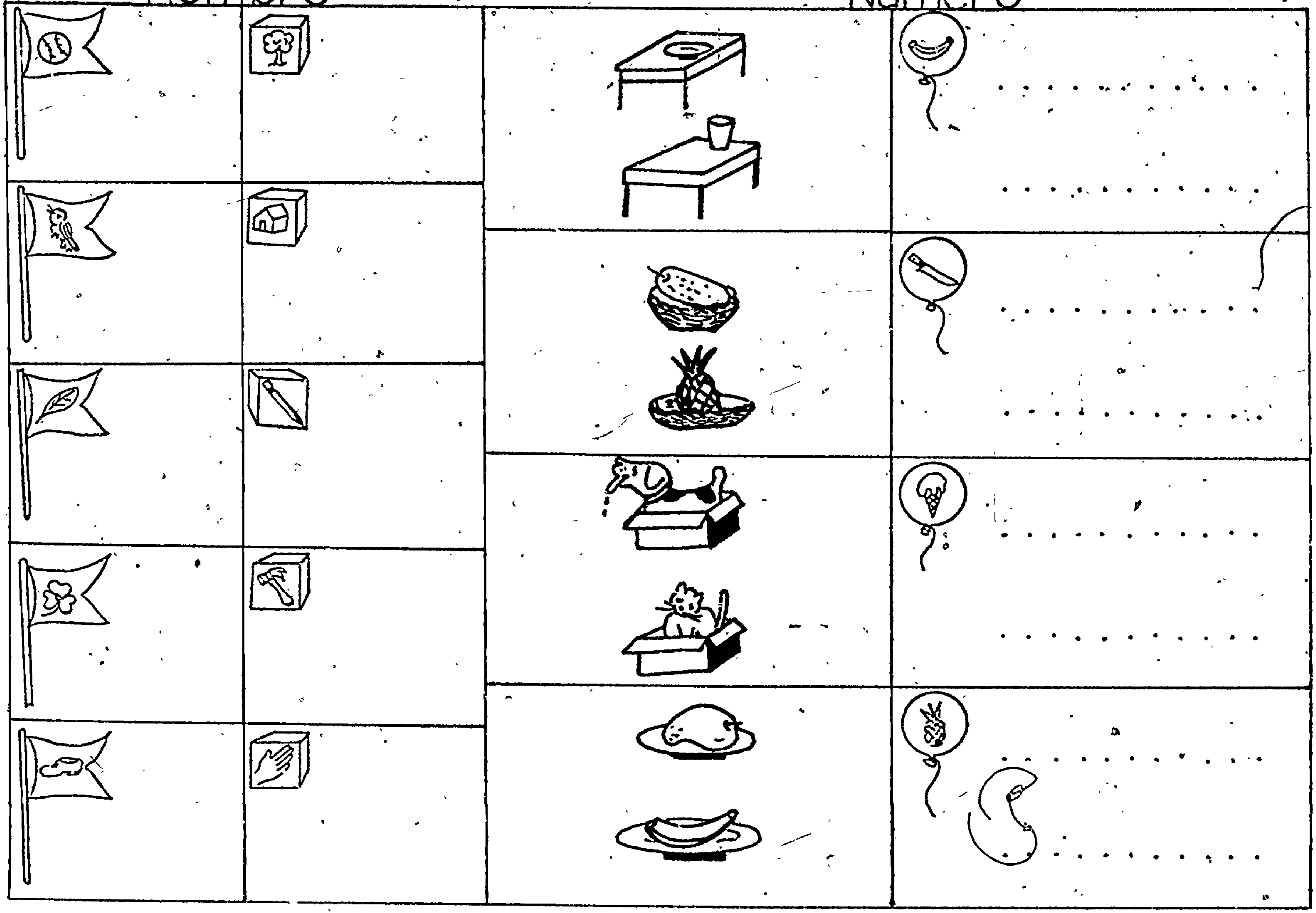
Seg. 1 "¿Cuánto es 2 más 2? (P) Vamos a probar que 2 más 2 son 4. Pongan 2 tapas en una mano y 2 en la otra... 2 tapas en una mano y 2 tapas en la otra mano. Pongan las manos juntas. ¿Cuántas tapas hay por todo? (P) Sí, 2 más 2 son 4."

Seg. 4 "Busquen la bandera que tiene la bola. Pongan un dedo en la bandera que tiene la bola. En ese cuadro escriban el número 4."

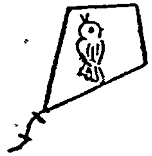
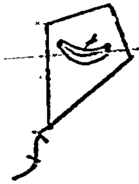
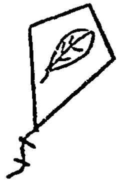
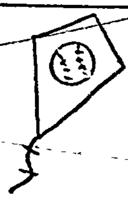
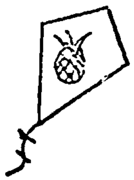
Seg. 5 "Busquen el dado que tiene el árbol. Pongan un dedo ahí. Ahora voy a preguntarles acerca de los números que van después de otros. Fíjense si tiene el dedo sobre el dado que tiene el árbol. No lo quiten porque en ese cuadro van a escribir un número. Díganme, número va después del 2? (Pausa) Escriban en el cuadro el número que va después del 2."

Seg. 7 "Busquen la chimbomba que tiene un banano. Pongan un dedo en la chimbomba que tiene un banano. En ese cuadro hay dos líneas de puntos. Sobre la primera línea de puntos dibujen tres rueditas (P) Ahora dibujen dos rueditas sobre la segunda línea de puntos. (P) Miren todas las rueditas que hay en ese cuadro. Díganme, ¿Cuántas rueditas hay por todo?"

18 Nombre Número



18

	1	2	3	4	5	6	7
	1	2	3	4	5	6	7
	1	2	3	4	5	6	7
	1	2	3	4	5	6	7
	1	2	3	4	5	6	7
	1	2	3	4	5	6	7

PROGRAMA MATEMATICA POR RADIO-

LECCION No. 19 GRADO 1 VERSION 1

FECHA GRABACION marzo 14, 1975 COPIAS

DURACION 22: 20

REALIZADA en: Radio Corporación, Managua.

VOCES:

Carlos

Lulú

Lobo

EFECTOS:

Tema Musical

Sonido Feria Vol. 1040, B-19

Sonido Palos

Sonido Caballitos Vol. 1017, B-1

Lección: 18
Grado: 1
Versión: 1

TEMA MUSICAL

FUNDE A

MUSICA TIPICA CON APLAUSOS Y MURMULLO - ESTUDIO

LOBO: (anunciando) Atención... Vengan todos a divertirse a la gran fiesta...

MUSICA SUBE Y QUEDA A FONDO

LULU: (ríe a carcajada) ¡Qué alegre! ¡Qué alegre!

LOBO: (llama retirado) Lulú, Carlos, vengan. Vengan con los niños. (retirado anuncia) Ventas, juegos...
¿Va a comprar, amigo?

CARLOS: Niños, que bueno, van a abrir las ventas.

LULU: ¡Mira, Carlos, cuantas cosas hay!...

CARLOS: (interrumpe) ¡Hm, que rico huele! Nacatamales y chicha... Mira ahí el chicharrón con yuca... el fresco de cacao, mangos y jocotes. ¡Qué rico!

LULU: ¡Ay, cuantas maracas y muñecas! Ay, ¡qué lindas! 5, 9, 11,... 20 (exclamación) ¡Qué montón! Compremos, compremos.

CARLOS: Mira, Lulú.

LULU: El lobo, cuantas cosas trae.

LOBO: Hola amigos. Miren, miren todo lo que me dieron... por andar trabajando en la barata... Pero no sé cuántas son.

CARLOS: Enseña, lobo. Enseña. Ah, cuántas son.

LOBO: Cuéntalas, Carlos.

sigue

Lección: 18
Grado: 1
Versión: 1

<u>LULU</u>: Que los niños las cuente, Carlos.

<u>LOBO</u>: Entonces, que me ayuden los niños porque mira, primero me dieron dos chimbombas y después me dieron tres... Bueno, yo creo que dos más tres son... cinco.

<u>MUSICA SALE</u>

<u>CARLOS</u>: Espera, probemos si es verdad. Atención, niños. Con una mano muestren <u>dos</u> dedos y con la otra muestren <u>tres</u>. Ajá. ¿Cuántos dedos son? (PAUSA) Eso es, porque dos más tres son cinco. ¿Y qué... más te dieron, Lobo?

<u>LOBO</u>: (inquieto) Ay, ay... miren, me dieron dos caramelos y después otros dos.

<u>CARLOS</u>: Niños, díganme. ¿Cuánto es <u>dos</u> más <u>dos</u>? (PAUSA -2) Eso es, cuatro. Pero vamos a probarlo. Con una mano muestren <u>dos</u> dedos... y con la otra muestren <u>dos</u> más... Ahora díganme, ¿cuántos dedos son? (PAUSA -2) Muy bien, dos más dos son cuatro.

<u>LOBO</u>: Ah, también me dieron candelas romanas. Primero me dieron tres y después dos.

<u>CARLOS</u>: A ver niños, ¿cuántos es tres más dos? (PAUSA -2)
Ahora, vamos a probar con los dedos.
Con una mano muestren <u>tres</u> dedos, y con la otra mano muestren <u>dos</u> más... Bien, ¿cuántos dedos son? (PAUSA -2)
Eso es, porque tres más dos son cinco.

LOBO: Ajá, candelas romanas. También me dieron gorras. Primero me dieron cuatro y después una.

CARLOS: A ver niños, ¿cuánto es cuatro más uno? (PAUSA -2)

Ahora probemos. Con una mano muestren cuatro dedos y con la otra muestren un dedo. ¿Cuántos dedos son? (PAUSA -2)

LOBO: Y miren me dieron banderas. Ay, pero poquitas. Primero me dieron yna y después dos.

CARLOS: Niños, ¿cuánto es una más dos? (PAUSA -2)

Ahora a probar. Muestren un dedo... ajá, con la otra mano muestren dos. ¿Cuántos hay por todo? (PAUSA -2) Eso es, uno más dos son tres.

LOBO: Que bueno, tres banderitas... Toma Lulú, una para tí, una para Carlos y la otra para mí... Cuantas cosas me dieron... Pero vengan... vamos allá... ahí van a ser las carreras de caballo.

LULU: Niños, también van a haber carreras... Vamos, vamos...

PUENTE MUSICAL

SONIDO : FERIA QUEDA A FONDO (VOL. 1040-B-19)

TODOS: ¡Cuántos caballos! (en tono bajo) Uno, dos, tres, cuatro.

LULU: Mejor contemos con los niños.

CARLOS: Niños, contemos.

Lección: 18
Grado: 1
Versión: 1

SONIDO PALO (PREC A CONTEO)

CARLOS: Una, dos, tres, cuatro, cinco, seis, siete, ocho, nueve, diez, once, doce, trece, catorce, quince... dieciseis... diecisiete... dieciocho... diecinueve... veinte.

LOBO y CARLOS: (ríen) Se movieron, Carlos.

CARLOS: Son veinte. Pero volvamos a contarlos. Niños, contemos otra vez.

SONIDO PALOS:

Uno, dos, tres, cuatro, cinco, seis, siete, ocho, nueve, diez, once, doce, trece, catorce, quince... dieciseis... diecisiete... dieciocho... diecinueve... veinte.

LULU: Ajá, son veinte caballos. (con asombro) Y todos los caballos tienen números. Mira van a mostrarlos.

CARLOS: Ahí va el cinco.

LOBO: Y ¿cuál va después del cinco?

CARLOS: Atención, niños, díganle al lobo que número va después del cinco. (PAUSA -2)

LOBO: Ajá, el seis. Pero mira ahí traen el ocho.

CARLOS: Niños, ¿qué número va después del ocho? (PAUSA -2) Eso es, después del ocho va el nueve.

LULU: Mira, ahora traen el siete.

CARLOS: Sí, es cierto. Niños, ¿qué número va después del siete? (PAUSA -2)

LOBO: Ajá, después del siete, va el ocho... Y ahora traen el nueve.

CARLOS: Niños, ¿qué número va después del nueve? (PAUSA -2) Eso es, después del nueve va el diez.

LULU: Ahora sí, traen el diez.

CARLOS: Vamos, niños, ¿qué número va después del diez? (PAUSA -2) Eso es, después del diez va el once.

LOBO: (triste) Ya no trajeron más. ¿Qué será?

LULU: Es que esos son los que van a correr.

LOBO: Entonces, vamos a ver las ruletas.

CARLOS: Sí, vamos a las ruletas.

SONIDO FERIA SUBE Y QUEDA A FONDO

LOBO: Las ruletas, Carlos. Las ruletas también tienen números. Juguemos.

CARLOS: Sí, juguemos, pero que los niños jueguen también.

LULU: Sí, que los niños nos lleven la cuenta de los números en que vamos a jugar.

LOBO: Y, ¿cómo Lulú?

SONIDO FERIA SALE

LULU: Verás, Lobo. Niños, tomen todos su hoja de trabajo. Busquen la cara que tiene su nombre. (PAUSA -2) En esa cara es donde vamos a trabajar. Busquen las banderas... Pongan el dedo sobre la bandera que tiene la bola de beisbol. (PAUSA -2)
Tomen su lápiz. En ese cuadro escriban el número cuatro.
(PAUSA -8)
Bajen el dedo a la bandera que tiene el pajarito. (PAUSA -2)
En ese cuadro escriban el número tres. (PAUSA -8)
Sigamos. Bajen el dedo a la bandera que tiene la hoja. (PAUSA -2)
En ese cuadro escriban el número cinco. (PAUSA -8)

Lección: 18
Grado: 1
Versión: 1

Ahora, bajen el dedo a la bandera que tiene la flor. En ese cuadro escriban el número dos.

(PAUSA -8)

Bajen el dedo a la bandera que tiene el zapato. En ese cuadro escriban el número seis.

(PAUSA -8)

LOBO: Ya, Lulú, sólo esos números van a jugar.

CARLOS: Bien. Niños, sigamos. Busquen los dados. ¿Los ven? (PAUSA -2) Ahora, busquen el dado que tiene el árbol. (PAUSA -2) En ese cuadro escriban el número que va después del dos. (PAUSA -8) Ahora, bajen el dedo al cuadro donde está el dado con la casita... En ese cuadro escriban el número que va después del uno. (PAUSA -8) Sigamos, bajen el dedo al cuadro donde está el dado con el lápiz. Escriban el número que va después del cuatro. (PAUSA -8) Ahora, bajen el dedo al cuadro que tiene el dado con un martillo. Escriban el número que va después del tres. (PAUSA -8) Bajen el dedo al cuadro donde está el dado con una mano. Escriban el número que va después del uno. (PAUSA -8)

LULU: Ya, Carlos. Ya terminamos con los dados. Ahora vamos con la otra parte.

LOBO: ¿Cuál parte, Lulú?

LULU: Con esta, Lobo. Aquí donde están las mesas. Niños, ustedes también busquen las mesas. La primera tiene un plato. ¿La ven? Ahora, díganme. ¿Qué hay en la segunda mesa? (PAUSA -2) Entonces encierren en un círculo la primera mesa. (PAUSA -5) Ahora, vamos al otro cuadro. Hay unas canastas. En la primera hay sandía. Y en la segunda, ¿qué hay? (PAUSA -2)

Niños, encierren la segunda canasta. (PAUSA -5)

Vamos a las cajas. Encierren la segunda caja. (PAUSA -5)

Y ahora, vamos a los platos. ¿Los ven? (PAUSA -2)

Encierren el primer plato. (PAUSA -5)

Y terminamos con esa parte---

SONIDO FERIA SUBE

LULU: Y el Lobo, ¿dónde está?... Lobo, ven. Sigamos trabajando... Se le olvidó que estaba trabajando.

LOBO: (retirado) No, Lulú, no se me ha olvidado. Es que aquí van a bailar. (ríe) Y yo quiero bailar.

FUNDE A

MUSICA TIPICA

CARLOS: No, Lobo, primero vamos a terminar con la hoja de trabajo. Ven, ven.

LOBO: (aproximándose) ¿Y qué vamos a hacer?

CARLOS: Ah, ahora vamos a dibujar.

LOBO: No... eso sí que yo no puedo. Dibujar no puedo, Lulú.

LULU: Ay, Lobo, si es bien fácil. Verás que bien dibujan los niños.

LOBO: ¿Dónde están las chimbombas?

MUSICA Y SONIDO SALEN

LULU: Sí, Lobo. Niños, busquen las chimbombas. Ahora, busquen la chimbomba que tiene un banano... Pongan el dedo sobre esa chimbomba (PAUSA -2) Fíjense. En ese cuadro hay dos líneas de puntos. Bien, sobre la primera línea dibujen dos rueditas. (PAUSA -12)

Lección: 18
Grado: 1
Versión: 1

Ahora, en la segunda línea dibujen una ruedita más. (PAUSA-12)

Miren bien todas las ruedítas. (PAUSA - 2)

Díganme, ¿cuántas rueditas dibujaron en ese cuadro? (PAUSA - 2)

Sigamos, bajen el dedo a la chimbomba que tiene el machete. En ese cuadro hay también dos líneas de puntos. En la primera línea dibujen una ruedita. (PAUSA -12) Ahora en la segunda línea dibujen tres. (PAUSA -12) Díganme, ¿cuántas hay por todo?

Bajen el dedo ahora a la chimbomba que tiene el sorbete. En la primera línea dibujen tres rueditas. (PAUSA -12) Ahora, en la segunda línea dibujen dos mas. (PAUSA - 12) Díganme, ¿cuántas dibujaron por todo? (PAUSA - 2)

Ahora, bajen el dedo a la chimbomba que tiene la piña... En la primera línea dibujen dos rueditas. (PAUSA -12) Y en la segunda línea otras dos. (PAUSA -12)

¿Cuántas dibujaron por todo? (PAUSA - 2)

Y terminamos con la hoja de trabajo.

LOBO: Ahora sí puedo seguir viendo bailar.

CARLOS: Sí, vamos a ver bailar.

SONIDO FERIA REPITE

LULU: Mejor vamos a montarnos a los caballitos.

LOBO: Ajá, ahí están todos mis amigos. Pero no me vuelven a ver.

LULU: (riendose) Cómo te van a volver a ver si son de palo, ven. Vamos, Carlos.

SONIDO: MUSICA CABALLITOS (VOL. 1017-B-1)

TODOS: (RIEN)

CARLOS: Apúrate, Lulú... Dame la mano. Sube, sube.

LULU: Sí... pero yo agarro este caballo que va muerto de la risa. (ríe) Ven, Lobo, agarra tú el toro.

LOBO: ¿No me cornea?

AMBOS: (ríen) Si no hace nada.

LOBO: (lucha por subir) No puedo, no puedo. Ay me escurro. Me voy a caer. Ayúdenme.

CARLOS: No te caes, agárrate bien.

AMBOS: (ríen)

LULU: (ríe a carcajadas) Va al revés, Carlos, (ríe) Niños, el Lobo se montó para atrás.

LOBO: Ay mamita. Todo da vuelta. Dios mío... por dónde voy... Paren, pa paren...

CARLOS y LULU (ríen)

SONIDO SUBE

FUNDE A

TEMA MUSICAL

Primer Grado

Lección Nº 18 (con grabadora)

Guía del Maestro

Materiales:

Hoja de trabajo Nº 18, tarjetas, con numerales de 1 a 9, material concreto: 10 objetos.

Actividades:

<u>Antes de la transmisión.</u>

Distribuya las hojas de trabajo Nº 18.

Diga a los niños que escriban su nombre y número.

Active la grabadora.

<u>Después de la transmisión.</u>

Diga a los niños:

Ahora trabajaremos en la segunda cara de la hoja de trabajo.

— Leer numerales de 1 a 7 y encerrar uno.

"Observen el cuadrito que tiene palometa con pajarito. ¿Qué números hay en ese cuadro?"

"Lean conmigo esos números."

Vean los demás cuadros.

¿Todos tiene los mismos números?

Pongan un dedo en el cuadro que tiene pajarito, de los números de ese cuadro, encierren en un círculo el 3.

En el cuadro que tiene palometa con banano, encierren el 6.

Donde está la palometa con hoja, encierren el 2.

En el cuadro de la palometa con bola, encierren el 4.

En el cuadro de palometa con sorbete, encierren el 7.

En el cuadro de palometa con piña encierren el 5.

Recoja las hojas de trabajo.

— Leer numerales de 1 a 9 con tarjetas.

a manera de adivinanza presente a los niños las tarjetas por el lado que no tienen número y diga por ejemplo: "Carlitos adivina qué número hay en esta tarjeta."

Dele vuelta a la tarjeta y pregunte a los niños

¿Qué número es? ¿Adivinó Carlitos?
Continue el ejercicio con las demás tarjetas del 1 al 9.

— Conteo cardinal del 1 a 10 con material concreto.
Coloque en su mesa 10 objetos que sean visibles por todos los niños.
Seleccione un niño y que pase a contar los objetos y los ubique en otra posición y que los demás niños repitan con él el conteo.
Repita el ejercicio las veces que estime conveniente, cambiando al niño que cuenta los objetos.

APPENDIX F

Design of Embedded Tests

Tests are included at regular intervals in the mathematics curriculum. These embedded tests have two purposes, to provide information to curriculum developers on the attainment of curricular objectives, and to provide the raw data for analysis of the progress of individual students through the curriculum. For the second purpose, it is important to have a measure of student progress that can be used to make comparisons between students.

To provide the basis for such a measure each instructional class is assigned a level number, the number of the lesson in which the class is first used. Items for each embedded test are selected so that the mean level of the instructional classes of which the items are exemplars is 80 percent of the number of the lesson containing the test. For example, the mean level number of the classes represented in the test in Lesson 41 is 32.8. With this method of item choice, the student test score, T, (defined below), has the property that if a student answers all items correctly over a series of tests, T increases linearly over the test series.

In order to describe the process of constructing an embedded test we need the following definitions.

DEF. Level of a class: The level of a class is the number of the lesson in which the class is first used. (Lessons are numbered consecutively starting with the first taped lesson.)

DEF. Testable class: At Lesson N a class is testable if

1. The level of the class is less than or equal to N, i.e. the class has been used by the end of Lesson N.
2. Exercises from this class have been administered by radio (not only by teachers) by the end of Lesson N.
3. Student responses to the exercises are written.
4. The class content represents a curriculum goal, not an intermediate objective.
5. The task is independent of context, e.g. does not depend on preceding exercises.

DEF. Active strand: A strand is active if it contains at least 3 testable classes of level less than or equal to N.

An embedded test is included in every fifth lesson, in Lesson N + 1 where N is greater than or equal to 20 and divisible by 5. To construct a test to be embedded in Lesson N + 1 do the following:

1. From each active strand, select all testable classes of level greater than or equal to N/2.
2. Select 10 classes such that
   a. the mean class level is 80 percent of N,
   b. active strands are represented according to the distribution displayed in Figure C2 (in text),
   c. the spread in class level is relatively large within each strand.
3. From each class to be tested, select a test item that fairly

represents the class, i.e. is neither the easiest nor hardest exercise in the class, if there is any difference in difficulty.

Step 1 restricts potential items to the more recent half of the curriculum. Because of the hierarchical nature of the mathematics curriculum, later instructional classes subsume the content of most earlier classes, and more useful information is likely to obtained by sampling later classes. Each test contains ten items (hence the requirement for ten classes), a compromise number arrived at by balancing the competing goals of obtaining information, and not dominating the lesson activities.

The test score T(s,j) for student s on test j is

$$T(s,j) = \frac{SUM(i=1,n)\ X(i)\ LN(i)}{n}$$

where n is the number of items on test j, X(i) takes on the value 0 or 1 for an incorrect or correct response, respectively, to item i, and LN(i) is the level number of the class of which item i is an exemplar (or, for short, the level of item i). Note that if the student answers all items correctly T is the mean of the level numbers of the items.

Test scores will provide a measure of progress through the curriculum. These measures can be related to information about individual students, such as attendence, pretest scores, age, rural or urban background, ability grouping within the classroom (if it is practiced) and so on, and also to prior performance in the course, using either prior test scores or daily worksheet performance.