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RADIO EDUCATION PROJECT

FIRST YEAR SUMMATIVE EVALUATION
SECOND GRADE MATHEMATICS

November 1988 - November 1989
Cochabamba, Trinidad, Kami
Bolivia

Submitted by:

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I. INTRODUCTION.

Experience in a number of projects around the world has demonstrated the power of an alternative-instructional model called "interactive radio instruction" to teach, motivate, and enrich the classroom environment at low-cost. Rigorous field evaluations of pilot-radio activities in Central America, Africa, and Asia have proven the "interactive radio methodology" to be a cost-effective mechanism for improving the efficiency, accessibility, and quality of both formal and nonformal education systems in developing countries. In addition, the radio lessons have helped to bridge the urban/rural learning gap in core subject areas, as the quality of rural education increases through the rigorously programmed intervention.

The Radio Education Project seeks to improve the quality of instruction in primary-school mathematics in Bolivia by adapting for use interactive-radio curricula previously developed and validated in other countries. In 1988, through the support of AID/Bolivia, AID/S&T/ED, and with the technical assistance of Radio Learning Project, Radio Education developed and broadcast 130 half-hour radio-mathematics lessons for approximately 10,000 second-grade students in 243 public-school classrooms in Bolivia. In addition, the project also developed a teachers' guide for use in directing complementary activities during the 15 minute postbroadcast session. Three of the country's nine departments participated in this inaugural phase: the Beni, Cochabamba, and Santa Cruz.

In order to assess the impact of the instructional-radio programs, we employed both qualitative and quantitative evaluation strategies. Formative evaluation was used on a daily basis to tailor the math programs to the average students' learning abilities, while summative evaluation was undertaken to measure student achievement. The results are now in and demonstrate that the Bolivian Radio Education Project has yielded the highest gains of any second-grade interactive-radio curriculum to date.

According to a recent World Bank Study[1] on educational efficiencies, the average effect size of the Bolivian interactive-radio curriculum package, .909, would place this program within the top 10% of educational interventions (radio, textbooks, and teacher training) evaluated in the developing world. (**Table 1.**)

This paper presents an overview of the second-grade summative evaluation strategy and results. Although the following discussion focuses largely on quantitative indicators, I have opened this report with a brief section on interactive-radio for the reader who may not be familiar with the innovation being evaluated.

II. INTERACTIVE-RADIO INSTRUCTION.

Interactive radio is different from other educational-technology alternatives because it is a breakthrough in instructional design combining the basic principles of educational psychology with the particular characteristics of radio. Interactive-radio lessons are designed to provide direct instruction to students. They systematically present and explain new material and review basic subject matter in an understandable, interesting, and pedagogically effective way. Each program includes intensive drill and practice, both oral and written, where students' responses are immediately reinforced by the correct answer. The lessons also introduce new learning concepts, engage students in problem-solving activities, and lead students to subject mastery through inductive and participatory activities. By carrying the burden of instruction, interactive radio allows the teacher to shift roles from classroom lecturer to individual tutor. Multigrade teachers may work with a different group of students altogether.

The radio lessons also help to enliven the classroom atmosphere through the use of stories, songs, learning activities, games, and physical exercises which invite the active participation of both students and teachers in the learning process. Teachers' own knowledge of basic subject matter is reinforced through the instructional radio programs. In addition, the programs provide in-service support for participating teachers through complementary postbroadcast activities.

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[1] Marlaine E. Lockheed and Eric Hanushek, "Improving Educational Efficiency in Developing Countries", World Bank Discussion Paper EDT 435, World Bank, Washington, D.C., 1988.

Effect of radio, textbooks and teacher training on student achievement in developing countries

Country	Sample: Grade	Sample: Year	Sample: N	Treatment	Design[a]	Outcome	Effect size	Average effect size
Radio								
Kenya (Oxford *et al.*, 1986)	St. 1	1982	2679	Radio Language Arts (RLA)	T/C	Reading test	.32	.53
						Listening test	.89	
	St. 2	1983	2734	(RLA)	T/C	Reading test	.29	
						Listening test	.66	
	St. 3	1984	2576	(RLA)	T/C	Reading test	.45	
						Listening test	.57	
Nicaragua (Searle & Galda, 1980)	1	1976	1009	Radio Math	T/C	Math test	1.31	.55
		1878	1286	Radio Math	T/C	Math test	.88	
	2	1977		Radio Math	T/C	Math test	.31	
		1978	681	Radio Math	T/C	Math test	.58	
	3	1976	877	Radio Math	T/C	Math test	.37	
		1976	836	Radio Math	T/C	Math test	.39	
	4	1977	733	Radio Math	T/C	Math test	.01	
Thailand (northeast) (Friend, Galda & Searle, 1986)	2	1980	812	Radio Math	T/C	Math test	.58	.58
Textbooks								
Brazil (Armitage *et al.*, 1986)	2	1981	3906	Use textbook 3 or more days per week	CS/MR	Reading and math test	.47	.34
		1983	3500				.30	
	4	1981	1410				.20	
		1983	1402				.39	
Nicaragua (Jamison *et al.*, 1981)	1	1978	1700	1 textbook/ student plus teacher guide	T/C	Math test	.36	.36
Philippines (Heyneman *et al.*, 1984)	1	1977	3200	1 or 2 textbooks/ student	T/C	Science test	.58	.40
						Math test	.31	
						Pilipino test	.33	
	2	1977	2825			Science test	.56	
						Math test	.41	
						Pilipino test	.21	
Thailand (Lockheed *et al.*, 1987)	8	1981	4030	Frequent use of textbook by teacher	LS/MR	Math test gain	.06	.06
Teacher Education								
Brazil (Armitage *et al.*, 1986)	2	1981	3906	In-service training (Logos II)	CS/MR	Student reading & math test	−.07	.09
		1983	3500				.25	
	4	1981	1410				.06	
		1983	1402				.10	
	2	1981	3906	Four years primary education	CS/MR	Student reading & math test	.07	.21
		1983	3500				.28	
	4	1981	1410				.27	
		1983	1402				.21	
	2	1981	3906	Three years secondary education	CS/MR	Student reading & math test	.06	.16
		1983	3500				.21	
	4	1981	1410				.20	
		1983	1402				.16	
Thailand (Lockheed *et al.*, 1986)	8	1981	4030	Each semester post-secondary math education	LS/MR	Student math test	<.01	<.01

Note

[a] T/C = treatment/control study design; CS/MR = cross-sectional survey/multiple regression analysis; LS/MR = longitudinal survey/multiple regression analysis.

Table 1.

Educational Efficiency in Developing Countries

Efficiency of six educational policies

	Effect size[a]	Cost per-student	Efficiency[b]
Textbooks			
Brazil[c]	.34	$1.65	.21/$1
Nicaragua[d]	.36	$1.75	.21/$1
Philippines[e]	.40	$ .27	1.48/$1
Thailand[f]	.06	$ .25	.24/$1
Radio education			
Kenya[g]	.53	$ .40	1.33/$1
Nicaragua[h]	.55	$1.80	.31/$1
Thailand (Northeast)[i]	.58	$ .44	1.31/$1
Teacher education			
Brazil (4 yrs primary)	.21	$2.21	.09/$1
Brazil (Logos II)	.09	$1.84	.05/$1
Brazil (3 yrs secondary)	.16	$5.55	.03/$1
Thailand (additional semester postsecondary)	<.01	$ .09	.06/$1
Technical-Vocational Secondary[j]			
Colombia (INEM)	.39	$ 98.00	.40/$100
Colombia (tech-voc.)	.33	$376.00	.09/$100
Tanzania (commercial)	.50	$272.00	.18/$100
Tanzania (technical)	−.37	$561.00	−.07/$100
Tanzania (agricultural)	−.20	$375.00	−.05/$100
Cross-Age Peer Tutoring[k]			
United States	.73	$212.00	.34/$100
Cooperative Learning[l]			
Israel	1.40	$85.00	1.65/$100

Note:

[a] The effect size is the average score difference between treatment and control groups divided by the standard deviation of the control group (Glass, McGaw & Smith, 1981).
[b] Efficiency is the effect size divided by the per-student cost.
[c] Source for Brazil: Armitage *et al.* (1986).
[d] Source: Jamison *et al.* (1981) for effect; Wells & Klees (1978) for cost.
[e] Source: Heyneman *et al.* (1985) for effect; Searle (personal communication) for cost.
[f] Source: Lockheed *et al.* (1987).
[g] Source: Oxford *et al.* (1986) for effect; Kemmerer & Friend (1985) for cost.
[h] Source: Searle & Galda (1980) for effect; Wells & Klees (1978) for cost.
[i] Source: Friend *et al.* (1986) for effect; Galda (1985) for cost.
[j] Source: Psacharopoulos & Loxley (1985).
[k] Source: Levin *et al.* (1984).
[l] Source: Sharan & Shacher (1986).

Marlaine E. Lockhead and Eric Hanushek, "Improving Educational Efficiency in Developing Countries". Reprinted from the Journal of Educational Psychology. vol 73, no. 4 (August 1981), pp. 556-567. published by the American Psychological Association.

III. FORMATIVE EVALUATION.

Wherever interactive radio instruction has been used throughout the world, children have responded with enthusiasm. Nevertheless, it is an important component of the evaluation plan to regularly visit classrooms using the radio broadcasts to assess how well the children are responding. These visits are also useful in determining how well the teachers are doing, both during the broadcasts and in leading the postbroadcast activities.

The formative evaluation has two objectives. The first is to assess the technical quality of the educational programs. Trained classroom observers in each of our three participating departments visit a representative sample of schools (not participating in the summative evaluation) on a randomized but daily basis. The purpose of their observations is to gather information on: 1) the audio quality of the programs, 2) the pacing of instructional material, 3) the appropriateness of the language used, 4) the timing of the pauses, 5) the level of student involvement in individual segments, and 6) errors in printed support material. This information is passed onto the central office on a weekly basis so that the curriculum and radio production teams can modify subsequent scripts or program delivery to the reality of the Bolivian classroom. For example, if students do not have enough time to respond orally during multiplication drills, the pauses may be lengthened in future lessons; or if students cannot follow the presentation of instructional material in one format (such as a short radio drama), that format might be dropped in favor of a more acceptable presentation like oral drill and practice.

The second function of the formative evaluation is to improve the instructional quality of the radio programs. Each lesson is observed on a daily basis by trained observers in three different parts of the country--Riberalta, Cochabamba, and Santa Cruz. Using an evaluation instrument which divides the radio program into learning segments (**Table 2.**), observations are recorded on student understanding of essential concepts taught by the radio. If students do not master the learning objective of a particular instructional strand, or if they continue to repeat the same mistake (because they are confused by the radio instructions), the original segments are revised and broadcast in future lessons. In addition, if teachers find a particular postbroadcast activity complex or difficult to administer, information may be passed onto the curriculum team so that a complementary segment can be developed and substituted.

In addition to using formative evaluation to fine-tune current programming, we also use the classroom observations to revise the curriculum package at the end of each school year. From October of 1988 through January of 1989, the curriculum team reviewed all field notes and made changes to the second-grade scripts accordingly. Less than 5% of the original lessons remained

untouched. Of the 95% that were changed, roughly 80% were done through minor editing in the recording studio, and only 15% had to be rerecorded. Now that the second-grade radio curriculum has been validated and improved, we anticipate that children participating in the second-grade course this year, and in future years, should do every bit as well or better than the original second-grade experimental cohort.

TABLE 2.

HOJA DE OBSERVACIONES LEC.NO. 60

SEGUNDO GRADO MATEMATICA"JUGUEMOS CON LOS NUMBERS"

Observador:_____ Lugar y fecha:_____

Escuela:_____ 2o._____ No.Alumnos_____

Profesor(a):_____ Inicio trans:_____Final:_____

Actividades ANTES de la transmision:

Actividades DURANTE la transmision:

Seg.1. Multiplicacion Oral (2 x 5)

Seg.2. Adicion Oral (30 + 1 + 8)

Seg.3. Multiplicacion/Pizarron/Cuadernos (12 x 4)

Seg.4. Adicion Oral (8 + 3 + 9)

Seg.5. Multiplicacion/Pizarron/Cuadernos (41 x 2)

Seg.6. Adicion Oral (82 - 80)

Seg.7. Adidion Dictado (6 + 9)

Actividades DESPUES del la transmision:

Actividades realizado por la guia:

Actividades hizo por iniciativa propria:

Otras observationes y comentarios:

IV. SUMMATIVE EVALUATION DESIGN.

The purpose of the summative evaluation is to measure the effectiveness of the interactive-radio mathematics curriculum in terms of learning outcomes. The second-grade summative evaluation has the following characteristics:

- A lapped-year experimental-control study design was used.
- Three regions (one urban, one rural, and one largely suburban) within two of the three participating Departments were included.
- 1,554 students in 50 randomly selected classrooms were tested.
- To avoid contamination through the Hawthorn effect, formative schools were not included in the summative evaluation.
- A comprehensive test measuring student achievement in mathematics at the second-grade level was designed to cover items included in the official Bolivian syllabus. The testing instrument and instructions were standardized.
- Data was collected on 39 variables for the final statistical analysis.

A. Lapped-Year Design.

For the purpose of our evaluation, we chose a "lapped-year" design rather than a "matched pair" design to ensure the closest match possible between control and experimental groups, and to avoid radio contamination of control schools. Under the lapped-year design, during the first year, the posttest is given to children who have completed one year of conventional mathematics and who have not been exposed to the radio treatment. At the end of the next school year, the posttest is given to different children but from the same neighborhoods, sometimes from the same family, at the same level, in the same classrooms, and sometimes with the same teachers, but after receiving one year of the treatment, that is one year of direct instruction in mathematics by radio. In this way, we were able to get a closer match between the control and experimental groups than if we had tried to pair two different sets of schools. In addition, we did not have to go through the difficulty of trying to match schools without sufficient data on teachers' qualifications, school quality, language, household literacy, and socioeconomic status.

By testing the control group prior to initial transmission of the radio lessons, we were able to control completely for contamination--the possibility that the control group students or teachers may have listened to the radio intervention or seen the

teachers' guide prior to being tested. In November of 1987, at the end of the traditional school year and prior to the transmission of any radio math lessons, we administered a mathematics achievement test to the control group cohort. These students had just completed second-grade using conventional mathematics instruction. In the beginning of the following school year, April 1988, the same classrooms became part of the experimental group as children in these classrooms were given the radio mathematics lessons in place of their regular math program. All other subjects were taught in the conventional manner. After one full school year's programming (April-November), we went back to the same schools and administered the same test to the children who had taken the radio mathematics lessons in place of their regular math program.[2] **Table 3.** is illustrative of our summative evaluation design.

TABLE 3.
Summative Evaluation - Radio Education Project (1987 - 1991).

SUBJECT	NOV 87	NOV 88	NOV 89	NOV 90	NOV 91
Mathematics Grade 2 (Cochabamba, Tridinad,Kami)	Control	Radio			
Mathematics Grade 3 (Sucre,Tarija)		Control	Radio		
Mathematics Grade 4 (La Paz,Pando)			Control	Radio	
Mathematics Grade 5 (Oruro,Potosi)				Control	Radio

One deviation from the above design will occur during test years two, three, and four when the Project will return to Cochabamba and test the original experimental-group cohort in an

[2] Note: although the same classroom is used in the two years, the students are not the same since the first group will have gone on to the next grade.

attempt to measure the cumulative effect of the treatment over time.

B. Sample Selection.

On April 4, 1988 we began broadcasting the radio math lessons over eight radio stations in the Departments of Cochabamba, Santa Cruz, and the Beni. Because of issues relating to access and materials distribution, most of our first-year participating schools were located within one hour of population hubs. One exception was Kami, a rural mining community about 4-5 hours northwest of Cochabamba. Rather than take a small sample from each department and end up with a largely urban population, we decided to try and cover all ground--urban, suburban, and rural; altiplano, valley, and tropics.

Kami was selected as the rural testing center because it is one of the most complex areas in which we work. In addition to being one of the poorest communities in the region, Kami has a fairly high percentage of native Quechua speakers. Many students learn Spanish from their teacher rather than from their parents. Because of its remote location, Kami has a constant turnover of teachers. Most of the teachers in Kami have just graduated from Normal School and are doing their first year of mandatory rural service. Once they finish with their contract, the teachers generally return to their own communities to seek further employment. Kami also has one of the worst records for the number of school days completed each year. Since Kami forms the hub of a transient community of miners and their families, schools will generally close for both teachers' strikes and miners' strikes. In addition, teachers work a four-day week, and are given one long weekend each month to go to the Departmental capital for administrative purposes. Because there is no reliable public transportation between the town and the capital, this weekend will sometimes extend into four or five days.

Cochabamba was selected as the urban/suburban testing center. We had initially planned to test in both Cochabamba and Santa Cruz; however, the academic year ended prematurely in the latter and we did not have sufficient time to mobilize our evaluation team. This did not pose any real problem as our 1987 pilot study (**Annex 1**) demonstrated that both teacher acceptance of the interactive-radio lessons and student learning gains bore similar results in the two regions. In addition, Cochabamba offered the advantage of having a large multicultural population which enabled us to test for a wider range of variables than would have been possible in Santa Cruz.

In the tropical lowlands of eastern Bolivia, we selected the city of Trinidad as our urban testing center. Like Santa Cruz, Trinidad has a fairly homogeneous population of native Spanish speakers; and although Trinidad is smaller and less developed than

Santa Cruz, it is more representative of the Amazonian basin. Population centers located further in the interior of the Department of the Beni were disqualified because of travel limitations. November is the start of the rainy season and air transportation beyond Trinidad is frequently suspended because of landing difficulties. Since our testing strategy required that both cohorts be tested during the last two weeks of the school year, we could not risk the possibility of not having access to our summative schools during that critical time.

Guayaramerin, Santa Cruz, and Riberalta, were chosen as sites for a secondary evaluation. Interested teachers in these areas were given the testing instruments to administer themselves after we had completed our summative testing. The corrected test results were then forwarded to the Project's central office in La Paz for inclusion in a secondary analysis. Questions about the validity of test administration and teacher interference, however, combined with our own strained resources have led us to put this analysis aside for the present time.

Based upon the summative designs used in previous interactive-radio projects, and in consultation with members of the Radio Learning Project's Advisory Board and the Education Office of AID's Science and Technology Bureau, it was decided that 1500 students was a large enough sample for statistical purposes. Within each testing center, summative schools were selected randomly from all schools which expressed interest in using the radio curriculum and were within receiving range of the radio transmitters. Both conditions were necessary for completion of the lapped year design which requires that the same schools be used for both control and experimental groups. Because of our two-week window on test administration, we further restricted the pool of summative schools to those schools within one hour's access of each testing center. The one exception is Kami, where the shortage of schools led us to include all schools within an hour's car ride from the mines. Schools which were not included in the summative group were then added to the pool of formative evaluation schools. **Tables 4-6** list the participating classrooms in the summative evaluation.

TABLE 4.
Grade 2. Summative Evaluation Classrooms: Cochabamba

CODE	SCHOOL	AREA	No. STUDENTS		% BILINGUAL		CLASSROOM MEAN		DIFFERENCE
			CONTROL	EXPER.	CONTROL	EXPER.	CONTROL	EXPER.	
CB 05A	Inmaculada Concepción	U	40	37	18%	0%	76%	84%	8%
CB 05B	Inmaculada Concepción	U	43	37	5%	0%	68%	75%	7%
CB 06A	Amor de Dios	U	47	47	2%	4%	69%	76%	7%
CB 06B	Amor de Dios	U	45	48	9%	0%	67%	82%	15%
CB 09A	Alfredo Jacobs	S	26	--	64%	--	43%	(a)	--
CB 09B	Alfredo Jacobs	S	26	--	46%	--	34%	(a)	--
CB 21A	Santa Luisa de Marillac	R	38	41	40%	100*	41%	74%	33%
CB 21B	Santa Luisa de Marillac	R	--	40	--	43%	(b)	75%	--
CB 22A	Humberto Portocarrero	R	9	39	100%	97%	48%	55%	7%
CB 23A	Sebastián Pagador	S	44	39	91%	0*	41%	62%	21%
CB 23B	Sebastián Pagador	S	41	39	78%	97%	45%	73%	28%
CB 23C	Sebastián Pagador	S	--	39	--	0*	(b)	69%	--
CB 23D	Sebastián Pagador	S	--	38	--	42%	(b)	56%	--
CB 24A	Ciudad del Niño	S	--	23	--	43%	(c)	77%	--
CB 24B	Ciudad del Niño	S	--	17	--	35%	(c)	68%	--
CB 24C	Ciudad del Niño	S	--	24	--	13%	(c)	73%	--
ALL COCHABAMBA			359	509	39%	26%	55%	71%	16%

(*) Language data not reported correctly. Presently collecting new data.
(a) School dropped from experimental group as radio signal too weak to receive programs.
(b) Santa Luisa de Marillac and Sebastián Pagador had more second-grade classrooms during the experimental year than during the control year.
(c) Ciudad del Niño included in experimental group as a match for Alfredo Jacobs.

- One month of schooling lost in both groups due to teachers' strikes.
- All Cochabamba schools completed 120 or the 130 radio lessons.

TABLE 5.
Grade 2. Summative Evaluation Classrooms: Trinidad

CODE	SCHOOL	AREA	No. STUDENTS		% BILINGUAL		CLASSROOM MEAN		DIFFERENCE
			CONTROL	EXPER.	CONTROL	EXPER.	CONTROL	EXPER.	
TD 01A	Pedro Ignacio Muiba	U	31	25	0%	8%	35%	54%	19%
TD 01B	Pedro Ignacio Muiba	U	21	22	0%	0%	47%	66%	19%
TD 02A	Santa Maria de Fe y Alegria	U	42	40	0%	0%	42%	67%	25%
TD 02B	Santa Maria de Fe y Alegria	U	39	42	0%	0%	43%	66%	23%
TD 04A	Juan Francisco Velarde	U	28	34	0%	0%	46%	78%	32%
TD 04B	Juan Francisco Velarde	U	27	33	0%	0%	37%	70%	33%
ALL TRINIDAD			187	196	0%	1%	42%	67%	25%

- One month of schooling lost in both groups due to teachers' strikes.
- Trinidad schools completed 120 of the 130 radio lessons.

TABLE 6.
Grade 2. Summative Evaluation Classrooms: Kami

CODE	SCHOOL	AREA	No. STUDENTS		% BILINGUAL		CLASSROOM MEAN		DIFFERENCE
			CONTROL	EXPER.	CONTROL	EXPER.	CONTROL	EXPER.	
CBK 12A	German Busch	R	14	23	79%	77%	23%	53%	30%
CBK 12B	German Busch	R	29	23	83%	70%	40%	56%	16%
CBK 13A	Gualberto Villarroel	R	30	29	90%	90%	35%	57%	22%
CBK 13B	Gualberto Villarroel	R	16	28	100%	96%	32%	41%	9%
CBK 17A	Constantino Velasco	R	11	19	100%	100%	13%	34%	21%
CBK 18A	Claudina Thevenet	R	15	22	100%	64*	30%	59%	29%
CBK 18B	Claudina Thevenet	R	17	24	100%	100%	35%	45%	10%
ALL KAMI			132	168	92%	86%	32%	50%	18%

(*) Incorrect language data. Presently collecting new data.
One month of schooling lost in both groups due to teachers' strikes.
Kami schools completed 90 of the 130 radio lessons.

C. Curriculum Review.

Prior to developing the summative testing instrument, the master plan of the Radio Mathematics curriculum and the official Bolivian curriculum were compared and contrasted to assess the degree to which the pretested radio programs would have to be modified to match the Bolivian curriculum; and to develop a preliminary pool of test items which could be used to design a comprehensive test of mathematics achievement. Through this activity, we were able to confirm that Bolivian school children entering Grade 2 should have the prerequisite skills needed to participate in the Radio Mathematics programs[3]; and that the Radio Math curriculum covers everything in the official Bolivian curriculum and more. Based upon this review, it was decided that mathematical skills prioritized in the official curriculum (addition, subtraction, multiplication, division, and fractions) would be taught by the radio, while areas of less emphasis (roman numbers and measurement) would be taught by the teacher in the 15 minute postbroadcast activity. **Table 7.** compares the scope and sequence of the original second-grade Radio Math curriculum with that of the official Bolivian curriculum and our adaptation.

D. Test Development.

Based upon the curriculum review, a comprehensive test measuring student achievement in mathematics at the second-grade level was developed from a pool of more than 100 test items used in previous Radio Mathematics projects. This was done so that in addition to measuring student achievement, a comparison could be drawn between the efficacy of the original interactive-radio curriculum and its adaptation in Bolivia. Although individual questions were selected from the Radio Mathematics item bank, it should be noted that the evaluation instrument was developed to measure student mastery of primary learning objectives expressed in the official Bolivian syllabus and not those concepts taught only by the radio.

The final testing instrument consists of 25 items, takes 35 minutes to administer, and includes mathematical items in numeration, addition, subtraction, multiplication, division, and measurement as well as word problems. Within the test, we tried to proportion items to instruction. For example, if numeration was prioritized in 15% of the official curriculum, it was given equal priority in our test. Column E of **Table 7** matches each test item with the particular learning objective to be measured.

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[3] Although our review of the Bolivian curriculum indicated that under normal circumstances, second-grade students should have the prerequisite skills needed to "take-off" with the radio mathematics lessons, we nevertheless began the series with a 20 lesson review of the basic concepts emphasized in first grade.

TABLE 7.
Scope and Sequence - Second-Grade Mathematics, Bolivia.

(A) THEME	(B) RADIO MATHEMATICS NICARAGUA	(C) BOLIVIA OFFICIAL	(D) BOLIVIA ADAPTATION	(E) TEST
NUMERATION				
Counting	To: 9.999	999	9.999 *	D
Reading Numbers	To: 9.999	999	9.999 *	CH
Writing Numbers	To: 9.999	999	9.999 *	D
Ordinal Numbers	To: 12th	10th	10th	E
Succesors & Predecessors	To: 9,999	999	999	A
LESS/GREATER THAN	To: 9,999	999	999	C
MONEY	Yes	Yes	Yes	J
FRACTIONS	1/2-1/10 Less/Greater Than Add & Subtract	1/2-1/4 No No	1/2-1/10 No No	G
ADDITION	To: 4 Columns Carry 3 Times	3 Columns Carry Twice	4 Columns Carry Twice	F,H,I,K M,V
SUBTRACTION	To: 3 Columns Borrow Twice	3 Columns Borrow Once	3 Columns Borrow Once	J,L,LL,S N,T
MULTIPLICATION	To: 9 as Multiplier Carry Once	To: 5 as Multiplier Yes	To: 9 as Multiplier Yes	N,P U
DIVISION	Short with Remainder	Short No Remainder	Short with Remainder *	R
TIME	Yes	Yes	Yes	O
LONGITUDE	Meter,Km Foot,Inch,Yard	Meter,Cm	Meter,Cm,Km	Q
GEOMETRY	Figures,Lines,Points Area	Yes No	Yes Yes	
Volume	Gallon,Liter,Cup	Liter	Liter	

* Introduction of advanced concept only.

To control for variations in test administration such as timing, vocabulary, pace of speech, and teacher interference, the instructions for the test were standardized, that is to say scripted and professionally recorded. Prior to going into the field to collect the baseline data, both the test and the instructions were pretested on a small group of 10 second-grade students pulled randomly from three Fe y Alegria classrooms in La Paz. Although La Paz is not representative of a cross-section of the Bolivian population, the short time allowed for this exercise prohibited us from conducting a more extensive pre-test in the field. During the testing session, care was taken to:

- Observe whether the language used in the test instructions was appropriate for second-grade students;
- Verify that participating students could follow the oral instructions without difficulty;
- Confirm that second-grade students would be able to follow the written format of the test without becoming confused:
- Evaluate whether the content areas of the test were appropriate for the second-grade cohort; and
- Assess whether the timing allowed for students to respond to each question was sufficient.

In sum, the students in the control group demonstrated no difficulty interpreting the test questions, and scored an average of 47% correct. This is within the range that we had expected (45%-55%) in order to guarantee that children in the experimental group would not "top-out", or illustrate top-heavy gains in the final evaluation. **Annex 2.** presents the summative test instrument and test instructions.

E. Test Variables.

A total of 39 test variables have been included in the analysis. Twenty-seven of the variables are directly related to the test itself, while 12 provide descriptive data about the student. A student data sheet was developed to collect additional information on each child relating to their history of school attendance, repetition, first language, sex, age, and location. Teachers were given the data sheets to complete while the children took the test. Meanwhile, a member of the Project evaluation team monitored student work during the actual test administration. A copy of the student data sheet follows (**Table 8.**) along with a list of descriptive data collected on each student. (**Table 9.**)

TABLE 8.

DATOS DEL ALUMNO
PRUEBA SUMATIVA
FE Y ALEGRIA

CB

FECHA:_____ REGION:_____

NOMBRE:_____

EDAD:_____

SEXO: _____MASCULINO _____FEMENINO

ESCUELA: _____ URBANA SUBURBANA RURAL

GRADO: _____

VA A PASAR LA MATEMATICA: _____SI _____NO

VA A PASAR EL GRADO: _____SI _____NO

HISTORIA DE REPETICION: (Escriba cuantas veces el alumno ha reprobado cada grado. Si no ha reprobado un grado, ponga un cero en la raya.)

PRIMER GRADO: _____

SEGUNDO GRADO: _____

FECHA DE MATRICULA: (Escriba la fecha en la cual el alumno se matriculo este ano escolar.) _____

ASISTENCIA A CLASE: _____EXCELENTE _____BUENA

_____SATISFACTORIA _____POBRE

_____MALA

IDIOMA QUE SE HABLA EN CASA: ESPANOL QUECHUA

AIMARA GUARANI

TABLE 9.
Test Variables.

VARIABLE	COMMENT
Region (Cochabamba, Trinidad, Kami)	Reliable
Group (control, experimental)	Reliable
School (by name)	Reliable
Classroom (by level)	Reliable
School days completed (by school)	Reliable
Urbanization (urban, suburban, rural)	Reliable
Student identification	Reliable
Student sex (male, female)	Reliable
Student age	Incomplete
Student repetition	Incomplete
Student attendance (excellent, good, normal, bad)	Subjective
Language spoken at home (Spanish, Quechua, Aymara, other)	Subjective

Most of the descriptive data that were collected are considered fairly reliable with the exceptions of student attendance and language. Although attendance is recorded daily in many classes, it is noted as an afterthought in others. In addition, how one defines normal and how one defines good is relative. Does good attendance mean that one's attendance is better than most, or are quantitative measures used? In many of the Bolivian schools, it is the former, and not necessarily the latter.

Language is also often misrepresented. The rule of thumb seemed to be: when in doubt note Spanish. Student data on language is not recorded in school registries, and a substantial number of teachers misinterpreted our question on language data. Teachers in Quechua speaking districts would note 100% of their children as speaking Spanish as a first language. If anything, our data on language is probably conservative, noting a higher percentage of native-Spanish speakers than there really are. Over the course of this school year, we will return to the schools in question to collect more accurate data on student language.

V. DATA ANALYSIS.

A. What is the effect of interactive-radio on mathematics achievement after one year of instruction?

The objective of the data collection effort is to assess the impact of the interactive-radio instructional methodology as an educational intervention. As a first step in the analysis of data, we measured the general mathematical achievement of second-grade students after one year of traditional (nonradio) instruction, and compared that with the year-end scores of the experimental cohort after one year of the radio treatment. (**Table 10.**) The average control group score was 47% correct while the mean experimental group score was 66% correct. The difference between the two means is 19%, a substantial gain. The t-statistic from the test of significance was 18.823, yielding a p-value of .000. This means that the possibility of the results being influenced by chance or by error are less than 1 in 1000, and that the statistical comparison is highly significant.

TABLE 10.
Comparison of Posttest Means - Control Group and Experimental Group

GROUP	YEAR	N	MEAN % CORRECT	STANDARD DEVIATION
Control	1987	679	47.00 %	21.23
Radio	1988	875	66.30 %	19.08

By plotting the mean posttest scores of both the experimental and control groups by deciles, one can quickly see the dramatic gains in student achievement demonstrated by the group having received one year of the interactive-radio treatment. A close look at **Table 11.** will reveal that nearly one third of all experimental school children scored within the top two deciles in comparison with less than 10% of the control group cohort. Furthermore, two thirds of the experimental group cohort scored more than 60% correct on the posttest, while only one third of the control group had comparative results. This means that twice as many experimental group students as control group students placed in the top four deciles. In fact, a larger percentage of experimental group children (68.5%) scored over 60% correct than did control group students who scored over 40% correct (65.4%).

TABLE 11.
Comparison of Summative Evaluation Posttest Scores by Deciles.

MEAN% CORRECT	CONTROL % SAMPLE	CONTROL (CUMULATIVE)	EXPERIMENTAL % SAMPLE	EXPERIMENTAL (CUMULATIVE)
80-100%	8.8%	(8.8%)	30.7%	(30.7%)
60- 79%	23.6%	(32.4%)	37.8%	(68.5%)
40- 59%	33.0%	(65.4%)	22.7%	(91.2%)
20- 39%	26.1%	(91.4%)	7.1%	(98.3%)
0- 19%	8.5%	(100.0%)	1.7%	(100.0%)

Because the final objective of the summative evaluation is to measure the impact of interactive-radio instruction over traditional (nonradio) instruction, the testing results should be interpreted through differences in mean scores rather than simple averages. The most effective way of measuring the efficiency of interactive radio as an instructional intervention is through its "effect size". Effect size is a powerful educational statistic because it can measure the impact of an intervention using criterion not directly affected by sample size. In other words, the effect size statistic can estimate how great the effect of the second-grade radio math program is in comparison with traditional instruction. To do this, we calculated the mean difference between the experimental and control groups in terms of the standard of deviation of the control group.

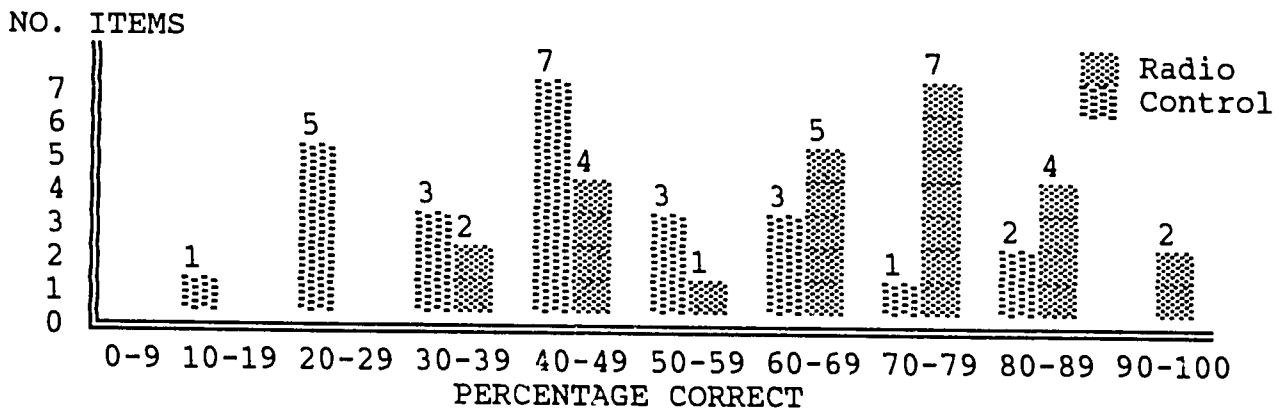
$$\text{EFFECT SIZE:} \quad \frac{\bar{X}E - \bar{X}C}{SD\ C} = .909$$

The result of .909 is dramatic proof of the beneficial effects of the interactive-radio lessons. Using **Table 1.** (Lockheed and Hanushek) as a frame of reference, the Bolivian Radio Education Project's second-grade radio-mathematics curriculum package would be among the most powerful instructional interventions tested in developing countries--more effective than teacher training, textbooks, or any other second-grade radio-mathematics curriculum to date.

Another way of interpreting the effect size statistic is to translate it into percentiles using statistical tables. With a .909 effect size, the average control-group student would be at the 50th percentile while the average experimental-group student would rank in the 81st percentile. This means that the benefit of having radio instruction over traditional instruction is an improvement of approximately 31 percentile points.

B. Using Item Score Differences to Assess the Benefit of Interactive-Radio Instruction.

This section looks at using item scores as a unit of measurement. **Figure 1.** graphically illustrates the superior performance of the experimental group over the control group by plotting the distribution of item scores for both groups by decile. For example, the experimental cohort scored between 70-79% correct on seven test questions, while the control group only scored one item within that range.



	DECILE	
	CONTROL	EXPERIMENTAL
Mode	40 - 49 %	70 - 79 %
Median	40 - 49 %	70 - 79 %
Mean	40 - 49 %	60 - 69 %
Range	10 - 89 %	30 -100 %

FIGURE 1. Distribution of Item Scores for Control and Experimental Groups.

Within the experimental group cohort, the item means for 18 of the 25 questions were above 60%. Among the control group cohort, only six of the 25 items had mean scores in the upper four deciles. In contrast, the control group had nine questions with item means of less than 40%, while the experimental group had only two. Within the control group, more test item means fell into the fifth decile (40-49%) than into any other, while the mode of the experimental group was between 70% and 79%--three deciles higher! The median decile for the control group is 40-49%, while the quantitative middle score for the experimental group is in the

seventh. The mean of the item means for each group is the same as their respective student averages (47.0% control group, 66.3% experimental group) indicating that a higher percentage of radio students have a greater mastery of second-grade mathematics than do control-group children instructed by traditional methods.

Perhaps a more effective way of looking at the impact of interactive radio on student achievement is to focus on item-score differences rather than the sample of item means. By doing so, one can eliminate the variation due to item difficulty. **FIGURE 2.** illustrates the distribution of mean score differences for the above data.

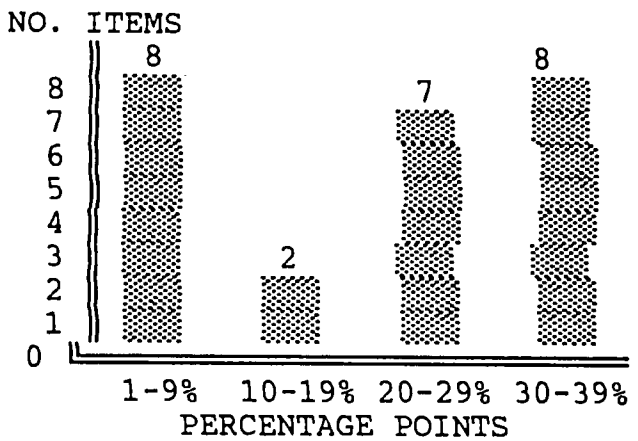


FIGURE 2. Difference Between Item Scores (Experimental minus Control).

As one can see from **Figure 2**, the experimental group outscored the control group on each test question. On ten of the questions, the item mean difference is from one to 19 points. This means that the experimental group scored up to 19% higher than the control group on each of the ten questions. An even more dramatic gain can be seen in the remaining 15 questions where the item means for the experimental group are from 20 to 39 percent higher than those of the control group. For example, the mean item score within the experimental group for test item H (73 + 6 = ___) is 70.4% correct, while the same item's mean among the control group is 37.8%. The mean item gain is calculated at 30.5%. This item would be included as one of the eight test items with a mean score falling within the fourth decile (30-39% correct).

C. What Effect does Urbanization have on Student Achievement?

Our control and experimental cohorts were next analyzed by location (urban, suburban, rural) to see what effect urbanization might have on student learning, and then to test the hypothesis that interactive-radio instruction has a positive impact on narrowing the urban-rural learning gap.

Socio-economic status plays a very significant role in defining educational parameters in Bolivia. There is a high degree of migration to Bolivia's cities. The best schools (and therefore best-paying jobs) are in the urban centers. Because of this, urban schools can afford to discriminate and generally accept teachers who are certified as specialists at the basic education level. These teachers have gone to normal school for certification or to a university for specialization, and have several years of teaching experience. Because these jobs are fairly limited and coveted, there is little turnover within the schools. Those teachers who may have gone to normal school but not to the university will more often be found in suburban areas. As a result, the quality of teaching is lower and turnover higher than in urban areas; however, there does exist some degree of continuity. The situation in the rural areas is very different with a fairly high turnover in teaching staff each year. All teachers must complete one year of mandatory rural service before they can be employed. As a result, many rural teachers are transient and inexperienced. It is said that there are only two types of rural teacher--the native teacher who has returned to his community because of a personal commitment, and the new teacher who isn't experienced enough for the suburbs.

Just as the quality of teaching is influenced by socioeconomic pressures, so too is the complexion of the school. Students in urban areas generally tend to be the children of literate parents who speak Spanish as a first language and work as professionals or public service/sector employees. In general, urban dwellers are better educated and better paid than rural residents. They also have wider access to primary health care. As a result, urban children may be healthier and better fed than rural children and therefore more alert and attentive during school.

Unemployment is higher in the suburban areas than in the cities. Parents of suburban children may not have gone beyond primary or secondary school. They probably speak Quechua or Aymara as a first language, but are fairly bilingual in Spanish. Those who are employed might work as unskilled laborers, domestics, or small-scale entrepreneurs. Outside of school, suburban children may use Spanish frequently in social and work activities, however they may also use both Spanish and Quechua in the household. Because of their proximity to the city, urban and suburban children share many experiences outside of school which might be foreign to rural children. For example, both urban and suburban children

would probably have more experience in dealing with money as either consumers or venders, and this could have a great influence on mathematics achievement.

In the country, a child has few opportunities to use Spanish outside of school. In poor rural areas, most parents speak Quechua and have little formal education. Children are responsible for contributing to the family economy. As a result, they may be taken out of school for substantial periods of time as work becomes available. In addition, political vibrations can also have a negative influence on school attendance. In communities like Kami, where all work is centered around one industry--mining, when the miners go on strike, the entire community joins in solidarity. In 1987, public schools in Kami only completed 53 out of 200 school days while Fe y Alegria schools completed 135 days.

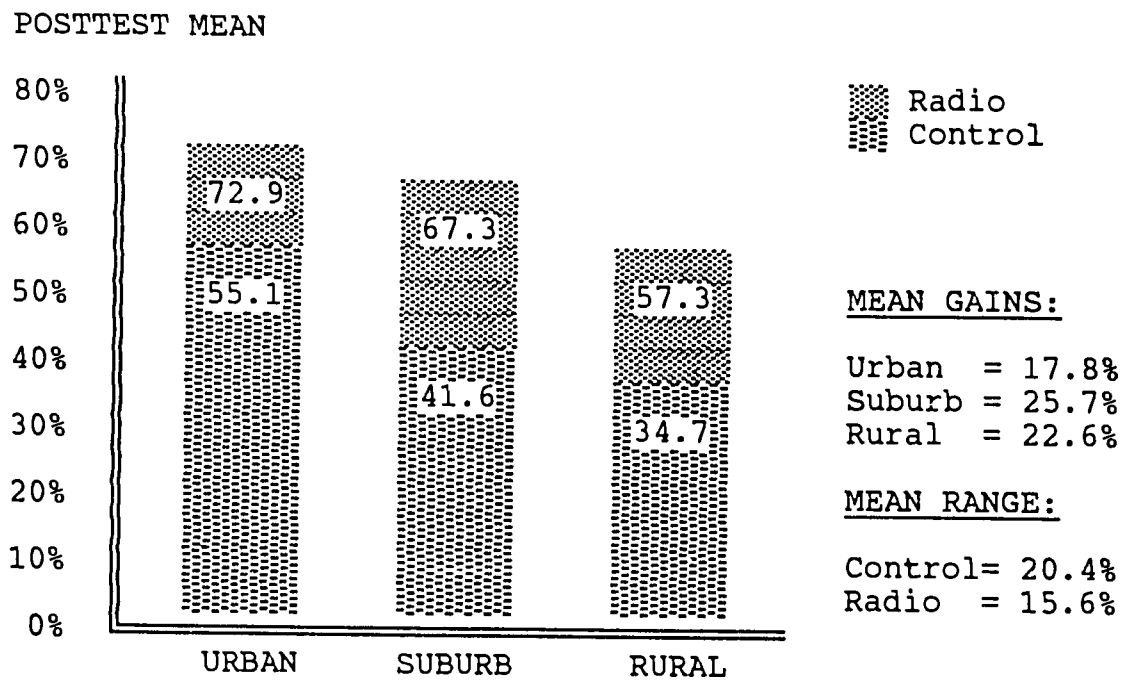


FIGURE 3. Comparison of Posttest Scores for Urban, Suburban, and Rural Students.

In all comparative subgroups, the interactive-radio students outscored the control-group children. The actual difference in posttest scores is most striking within the control group where each subgroup's mean score declines by one decile the further away it is located from the city. The quality of education in the urban subgroup is the highest with a mean sample score of 55.1% correct. The suburban subgroup comes next with an average of 41.6% correct,

while the rural subgroup is last with an overall mean score of 34.7% correct.

In addition to improving the quality of in-school mathematics, interactive radio is also working to make primary-school education more equitable. The distribution of learning gains across urban populations in Bolivia follows the same pattern that has been established in other countries using interactive-radio. The highest learning gains (25.7% and 22.6%) are in the suburban and rural areas where traditional teacher-led instruction is the weakest, while the lowest mean gains (17.8%) are in the urban areas where you generally find better students, better teachers, and better schools. In fact, the average score for rural students in the experimental group (57.3%) is higher than the overall mean score for urban students in the control group population (55.1%). One can also find evidence of interactive radio's impact on equalizing urban-rural instruction by comparing the range of mean scores among each group. The range of subgroup mean scores within the control group varies by 20.4 percentage points and goes from 55.1% in the urban schools to 34.7% in the rural schools. The range of subgroup mean scores within the experimental group is more narrow and goes from 72.9% in the urban areas to 57.3% in the rural areas for a total variance of only 15.6 percentage points.

D. Language and Student Achievement in Mathematics.

Although there seems to exist some relationship between location and language, and also between location and achievement, the actual correlation between language and learning is more difficult to prove.

TABLE 12.
Percentage of First-Language Spanish Speakers by Region and by Subgroup

REGION	URBAN		SUBURBAN[4]		RURAL[4]	
	CONTROL	RADIO	CONTROL	RADIO	CONTROL	RADIO
Cochabamba	92.0%	98.8%	26.5%	82.2%	48.9%	20.9%
Trinidad	100.0%	99.0%	-	-	-	-
Kami	-	-	-	-	8.3%	14.5%

[4] Language data is now being reviewed in rural and suburban Cochabamba for lack of confidence in original reporting.

TABLE 13.
Language by Testing Group

GROUP	% SPANISH SPEAKING	MEAN TEST SCORE	% BILINGUAL	MEAN TEST
Control	62 %	52.6 %	38 %	38.0 %
Radio	69 %	70.4 %	33 %	56.6 %
Mean Gain		17.8 %		18.6 %

I will not go into much analysis of the above data for lack of confidence in the original data set. One can, however, see from **Table 13** that there does seem to be some relationship between language and posttest scores. Children who have Spanish as a first language did better than bilingual children in both groups. Is this, however, a result of language, location, or both? Do Spanish speaking children do better because they live in urban centers where there are better schools and better qualified teachers? Do bilingual children do more poorly because they do not have a good command of the Spanish language, or because they have weak teachers who do not teach well? To what extent does the high number of strike days and student/teacher absenteeism affect the scores of the bilingual cohort who live in rural areas? Interestingly enough, the mean gain of each group are comparable, indicating that the bilingual students were able to take equal advantage of the radio instruction.

In one variation of the test, we divided one classroom in Kami into two sections. One group took the recorded test in Spanish and the other was given an oral version translated into Quechua. All students in both groups spoke Quechua as a first language. We found the overall scores for both groups to be very close. The Spanish group scored an average of three questions out of 25 correct, while the Quechua group scored an average of four. Does this mean that language is not the influencing factor? Could it mean that the quality of instruction that these children received in first and second grades was so low that they did not have the prerequisite learning skills to solve the problems no matter which language the test was given in? Maybe the children lacked the needed skills not because their teachers were bad teachers, but because their teachers could not communicate with them in their own language? It is more likely that the answer consists of any number of interrelated factors.

E. Comparing the Effect of Student Attendance on Achievement

Table 14. illustrates the basic correlation between student attendance and student achievement. Here one can see the relationship between the number of programs taken and the final test score: The better the attendance, the better the score.

TABLE 14.
Student Attendance and Posttest Scores.

ATTENDANCE	$\bar{X}$ CONTROL	$\bar{X}$ RADIO
Very Good	62.5 %	73.9 %
Good	46.1 %	67.6 %
Regular	42.4 %	55.7 %
Poor	33.9 %	55.0 %
Mean	47.0 %	66.3 %

F. Comparing Gain Scores between Bolivia and Nicaragua.

The Bolivian radio math programs were adapted from the radio-mathematics curriculum developed in Nicaragua in 1977. This section takes a look at whether the instructional integrity of the original programs have been maintained throughout the adaptation in Bolivia.

Figure 4. compares the final posttest results of the original radio mathematics second-grade curriculum developed in Nicaragua and its adaptation in Bolivia. It should be noted that while the two tests shared 24 items in common, they are quite different. In Nicaragua, a matrix sampling design was used and more than 100 test items included, while the Bolivian design used but one test consisting of 25 items. Overall, both experimental-group cohorts reached a comparable level of achievement even though the Nicaraguan curriculum consisted of 175 radio lessons and the Bolivian curriculum was reduced to 130. In conclusion, it would seem that the integrity of the original instructional series was not only maintained but perhaps improved upon through careful adaptation in Bolivia.

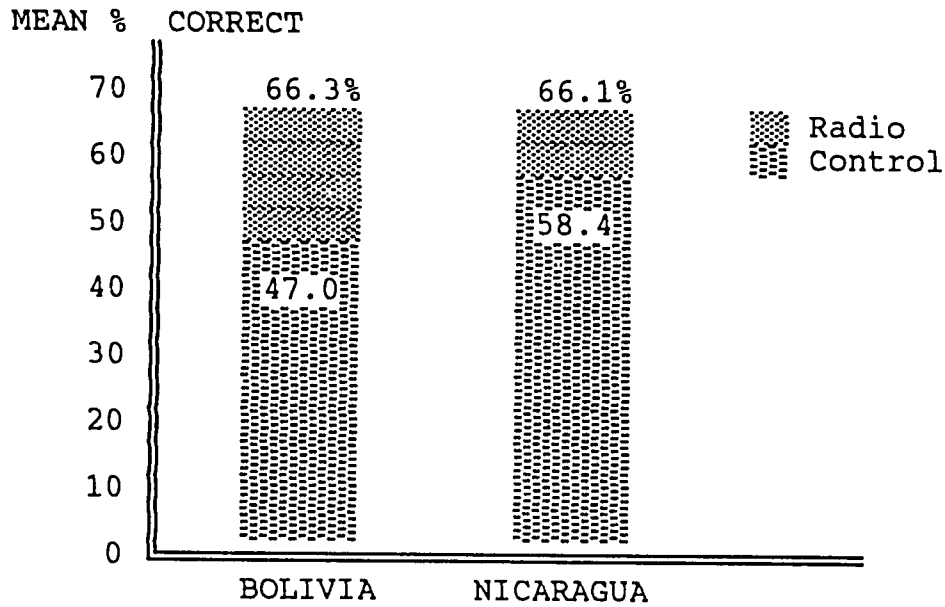


FIGURE 4.
Comparison of Posttest Means for Experimental and Control Classrooms, Bolivia and Nicaragua.

A second comparison can be made by looking at the efficiency of the radio intervention in each country. **Table 15.** compares the effect size of the original Nicaraguan second-grade curriculum (1976), its adaptation in Thailand (1980), and its adaptation in Bolivia (1988). Although the impact of the interactive-radio treatment is very high in all three cases, it is the strongest in Bolivia. Based upon this final evaluation we could safely state that the Bolivian adaptation has resulted in a hybrid version of the original Nicaraguan series; however, it would be difficult to claim with 100% certainty that they are significantly better. We can, however, say with full confidence that the dramatic gains demonstrated in the Bolivian project indicate that the interactive-radio methodology, as an educational innovation, had a stronger impact on improving student achievement in Bolivia than it did in the other countries.

TABLE 15.
Comparison of Effect Size: Radio Mathematics - 2nd Grade, Nicaragua, Thailand, Bolivia.

Nicaragua	(1978) :	.58
Thailand	(1980) :	.58
Bolivia	(1988) :	.91

The Bolivian posttest and the Nicaraguan test item pool had 24 questions in common. **Table 16.** compares individual test item means for both countries. In all questions, the Bolivian experimental group scored higher than the Bolivian control group. Of additional interest is the fact that both experimental groups scored equally well, overall, on three of the four major mathematical operations (addition, multiplication, and division). The Bolivian cohort did better than the Nicaraguan students; however in subtraction, numeration, and word problems, the Nicaraguan cohort demonstrated superior performances.

TABLE 16.
Comparison of Individual Test Item Means: Nicaragua, Bolivia

TEST ITEM	GROUP	BOLIVIA MEAN	NICARAGUA MEAN
A -Write number that comes after 71	Control	54.1	70.8
	Radio	74.1	77.9
B -Count the beans in the box, write number on line	Control	75.4	86.7
	Radio	83.3	86.7
C -Circle the largest number (923, 479, 150)	Control	44.7	60.2
	Radio	69.4	69.6
Ch-Circle the number 241 (142, 421, 251, 241)	Control	86.7	92.1
	Radio	91.7	96.4
D -Write the number 237	Control	84.7	81.3
	Radio	93.0	92.3
E -Circle the 8th soldier	Control	33.3	57.1
	Radio	36.0	66.0
F - 504 +132	Control	62.5	63.5
	Radio	85.1	73.0

G -Circle the figure divided in halfs	Control Radio	32.0 62.9	76.8 85.5

Include citation To Nicaraguan Radio Math Book (Red)

H - 73 + 6 =	Control Radio	37.8 70.4	69.1 67.3
I -Roberto arrived at 8:00. Luis arrived 2 hours later. What time did Luis arrive?	Control Radio	23.3 40.5	44.6 69.8
J - 376 - 56	Control Radio	47.1 77.4	43.4 65.8
K -How much is 800 plus 25?	Control Radio	17.1 40.3	33.0 64.2
L - 60 - 40 =	Control Radio	29.6 63.3	48.7 63.9
LL-How much is 70 minus 60?	Control Radio	21.5 54.4	56.3 56.6
M - 64 +28	Control Radio	49.0 80.3	61.1 71.5
N -How much is 2 times 3?	Control Radio	48.1 76.6	71.4 87.4
N - 82 -59	Control Radio	21.5 46.5	23.9 47.5
O -Which is the longest? (Mes, Dia, Ano) \	Control Radio	67.4 69.9	88.2 87.4
P - 32 x 3	Control Radio	50.7 83.8	63.5 76.6
Q -_____cm = 1 metro	Control Radio	44.4 66.9	50.4 44.6
R - 6 | 2	Control Radio	49.0 70.4	59.3 67.1
T -Robert's mother made 12 cookies and Robert ate 5. How many cookies are left? (5, 12, 17, 7)	Control Radio	65.9 76.6	72.3 86.6
U -Juan bought 4 chickens at 3 Bs each. How much did he	Control Radio	44.8 46.6	68.5 64.5

pay? (9, 12, 3, 7)			
V -Emilio ate 3 peaches then ate 3 more. Robert ate 5. How many did they eat? _____	Control Radio	57.5 64.2	84.7 83.5
MEAN ITEM MEAN[5]:	Control Radio	49.0 68.0	63.7 72.6

It is interesting to note that two of the areas in which the Bolivian experimental group showed the least gains were topics included in the official Bolivian curriculum and left up to the teacher to teach in the postbroadcast activity rather than taught by the radio. In item E, ordinal numbers, the control group scored 33.3% correct while the experimental group only scored 36.0%. Such low scores in both groups would seem to indicate that teachers, in general, do not place much importance on the teaching of ordinal numbers and therefore do not emphasize this concept in their classrooms. In the second item, the concept of time, the control group scored 67.4% and the experimental group 69.9%. The high scores in both groups on this item would seem to indicate the opposite, that is to say that both groups of teachers placed a high degree of emphasis on teaching this topic. If any conclusion is to be drawn, it might be that teachers tend to prioritize their time by teaching to those topics that they consider most important, regardless of the emphasis placed on the subject in the official curriculum, or in the teachers' guide.

F. Teachers' Observations.

Summary meetings were held with teachers in all locations. The purpose of these meetings was for teachers to share their impressions and criticisms of the programs with the project staff so that we could incorporate their observations into the final revision of the second-grade materials. In general, teachers noted that the radio students seemed to be more alert and actively involved in the learning process than were children in traditional classes, and that children had no difficulty in keeping-up with the pace of the radio instruction. Many professors commented that childrens' ability to think critically was also heightened through the instructional radio programs. Other teachers remarked that they felt the educational radio programs were contributing to the

[5] The mean item mean is for the 24 test questions found on both the Bolivian and Nicaraguan summative tests and differs from the overall means for all test items and all students as reported earlier.

and master concepts that went beyond the official Bolivian curriculum (such as the multiplication tables beyond five). And others said that they themselves have learned more about mathematics because of the programs.

A major criticism of the program was that teachers' felt that the radio lessons were too demanding on them. They claimed that the preparation required for each lesson (of reading the teachers' guide and leading postbroadcast activities) was a lot of work. Another criticism was that the programs are too generic and therefore difficult to identify with. Teachers from Santa Cruz wanted to hear more of their style of music in the programs, and teachers from Riberalta wanted characters who talked with the same clip as they do. These suggestions were addressed in the revision of the programs through the insertion of a wider variety of music into the lessons, and the creation of short "radio dramas" which take place in the different parts of the country. For the third grade programs, we are beginning to integrate "radio teachers" from different regions into our permanent staff of actors.

VI. FUTURE ACTIVITIES.

In an attempt to maintain the quality of our program adaptation, an extensive analysis of individual item errors is planned during the course of the year, should funding become available. In addition, a second look at the relationship between language and student achievement will resume upon successful collection of the Cochabamba student data. Analysis of the third-grade control group data collected in the Departments of Sucre and Tarija during November of 1988 has begun in preparation for comparison with the experimental group data to be collected in the same schools during November of 1989.

ANNEX 1.
Summary of the Bolivian Pilot Study.

In early 1987, Fe y Alegria conducted a pilot study to assess the feasibility of using interactive radio instruction to improve basic primary education in Bolivia. Their objectives for implementing the study were to: 1) verify that Bolivian school children can learn mathematics by radio; 2) evaluate whether the radio mathematics curriculum and lessons originally developed in Central America are appropriate for adaptation in Bolivia; 3) see if Bolivian teachers would be able to use the interactive-radio programs effectively with a minimal amount of training; and 4) assess Fe y Alegria's ability to implement the project institutionally, administratively, and technically.

Funding for the pilot was provided through AID/Bolivia; technical assistance in lesson adaptation, program evaluation, teacher training, and interactive-radio production was provided through the AID/S&T/ED funded Radio Learning Project; and counterpart resources, home-office support, and pilot implementation sites were contributed by Fe y Alegria.

Over the four-month trial period (April-July) we adapted, produced, and field tested 20 radio mathematics lessons (one-half hour each) in 11 second-grade classrooms in Cochabamba and Santa Cruz. We also trained 35 teachers and school directors in classroom use of the new interactive-radio programs. Gains in student mastery of those concepts taught by the radio were measured through the administration of pretests and posttests in all participating schools. Classroom observations were conducted in an average of two schools each day and teachers' impressions were gathered through written questionnaires and in focus group interviews.

In sum, we concluded that:

1) Bolivian school children can learn mathematics by interactive radio.

Teachers noted that the radio students seemed to be more alert and actively involved in the learning process than were children in traditional classes. By distributing key learning segments over time, children were able to keep-up with the pace of instruction rather than become lost in massed delivery. Many professors commented that children's ability to think critically was also heightened through the instructional radio programs. Other teachers remarked that they felt the educational radio programs were contributing to the development of second language skills within the bilingual population. Data collected during the summative analysis of the pilot activity indicate a correlation between language and student achievement. The higher the

percentage of native language speakers (Quechua) in a particular class, the lower the aggregate score on the pretest and the higher the aggregate sum gain on the posttest. Although the development of second language skills through mathematics instruction by radio was not one of the principle objectives of the study, and therefore not controlled for, it is one of many variables that we have included in the Project's summative evaluation. **Tables 1-2** reflect the dramatic gains in student mastery of those concepts taught by the radio.

2) The interactive radio instruction mathematics curriculum matches the official Bolivian curriculum. In fact, it covers even more.

The level of instruction in the radio programs was appropriate for the children participating in the pilot. While pretest results illustrate that pilot children did not have a good command of those subjects to be taught by the radio, the spectacular posttest results indicate that the Bolivian children did have all of the prerequisite learning skills needed to "take-off" with the radio instruction.

3) Bolivian teachers can effectively use the interactive-radio lessons in their classroom with a minimal amount of training.

During the pilot study, participating teachers were given one day's training before beginning the radio programs. During this time they were familiarized with the classroom materials, radio programs, testing instruments, and postbroadcast activities. Throughout the pilot, classroom teachers demonstrated a high degree of competence in their use of the instructional radio programs.

4) Fe y Alegria has the institutional capacity to handle the technical and administrative aspects of the project with continued technical assistance.

A technical evaluation completed by the Radio Learning Project confirmed Fe y Alegria's ability to implement the project with on-going technical support. Continued access to technical assistance was designed to allow Fe y Alegria to develop their in-house expertise in the areas of curriculum development, distance education, project administration, and project management.

Based on the strength of the pilot results Fe y Alegria and Radio Learning Project have joined together to adapt and nationally dissseminate the entire interactive-radio curricula for mathematics (grades 2-5). The project goal is to provide high quality instruction at the primary school level through national dissemination of locally adapted and developed interactive-radio curricula. Three major outcomes are expected. First, the project will significantly improve student learning in mathematics.

Second, the project will also improve the capabilities of the teachers to teach these critical subjects. Third, the radio programs will make the school experience more enjoyable. Of equal importance is the development of Fe y Alegria's institutional capability to mobilize national support for the instructional radio programs. The administrative structure of Fe y alegria must be strong enough to support initial project implementation activities and act as a springboard for further dissemination.

Table I

BOLIVIA PILOT RESULTS
Grade Two Mathematics: Lessons 1 - 20

Code	Region - School	First Language		TEST	
		Spanish	Quechua	Pre	Post
	Cochabamba			May 12 & 13	June 16 & 17
CB1	El Salvador	11%	89%	42%	80%
CB2	Obispo Anaya	23%	77%	51%	91%
CB3	Jesus Ma. A	73%	27%	77%	95%
CB4	San Francisco	64%	36%	66%	92%
CB5	Maristas	53%	47%	65%	90%
CB6	Tacata (2)	67%	33%	49%	93%
	AVERAGE	49%	51%	59%	90%
	Santa Cruz			Jun 8	July 7 - 8
SC1	La Morita	100%		60%	89%
SC2	America	100%		76%	90%
SC3	SC La Sierra	100%		68%	84%
SC4	Mariscal Sucre	100%		72%	91%
SC5	Montero	100%		71%	93%
	AVERAGE	100%		69%	89%
OVERALL AVERAGE				64%	90%

1 Strike Days: CBBA - 8, SCZ - 16
2 Tacata (Grados 2 and 3) 57% - 95%

Table II

Analysis of Three Concepts - Bolivia Pilot Test, 1987

		REGION/SCHOOL												
Concept	Test	CB1	CB2	CB3	CB4	CB5	CB6		SC1	SC2	SC3	SC4	SC5	Average
Tens & Ones	Pre	0	0	24	12	7	17		11	52	34	0	3	15
*** = 30	Post	94	85	100	92	75	90		74	68	67	77	70	81
Writing	Pre	3	4	46	67	27	92		36	70	9	13	31	36
3 Dig.#'s 212	Post	25	77	92	93	70	100		85	84	61	75	88	77
Zero	Pre	22	31		60	51	33		39	55	51	67	51	46
4 - 0 = 4	Post	86	85		78	77	100		82	97	67	98	94	86

ANNEX 2.

Second Grade Testing Instrument and Instructions.

Nombre: _____

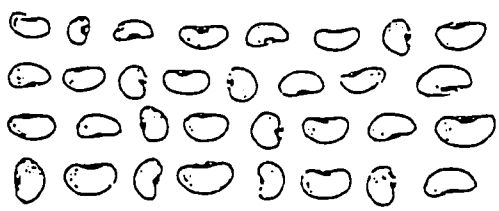
Código

A

71 ___

B

___



C

923 479 150

CH

142 421 251 241

D

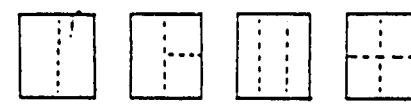
_____

E

F

$$\begin{array}{r} 504 \\ +\ 132 \\ \hline \end{array}$$

G



H

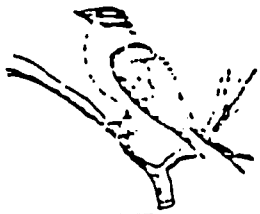
73 + 6 = ___

I

_____

J

$$\begin{array}{r} 376 \\ -\ 56 \\ \hline \end{array}$$



K _____	P $\begin{array}{r} 32 \\ \times\ 3 \\ \hline \end{array}$
L 60 − 40 = ___	Q 1 Metro = ____ centímetros.
LL _____	R 6 | 2
M $\begin{array}{r} 64 \\ +\ 28 \\ \hline \end{array}$	S _____
N _____	T 5 12 17 7
Ñ $\begin{array}{r} 82 \\ -\ 59 \\ \hline \end{array}$	U 9 12 3 7
O mes día año	V _____

Prueba de Fin de Ano, Segundo Grado
28 de octubre de 1987

Hola ninos! Hoy vamos a hacer juntos unos ejercicios de matematica - ejercicios de adicion, de sustraccion, de conteo, de...todo. Voy a explicar que es lo que ustedes van a hacer. Pero primero, tienen que prestar mucha atencion y guardar silencio.

Empecemos. Pongan su lapiz sobre la mesa y no lo vuelvan a tocar hasta que yo les diga.

(PAUSA :04)

Ahora, miremos la hoja de respuesta. Encuentren el lado que tiene un arbol en la parte de arriba.

(PAUSA :03)

Bien. Fijense que la hoja de respuesta esta dividida en cuadros. En cada cuadro hay una letra. Busquen el cuadro con la letra "A". Observen que la "A" esta debajo del arbol. Pongan el dedo en la letra "A".

(PAUSA :04)

En ese mismo cuadro de la letra "A", hay un numero y una raya en blanco. Ahora, bajen el dedo a la letra "B", la "B".

(PAUSA :04)

En ese cuadro hay una raya. Debajo de la raya hay unos porotos... Bajen el dedo a la letra "C", la "C".

(PAUSA :04)

En ese cuadro hay varios numeros...
Bajen el dedo a la letra "CH", la "CH".

(PAUSA :04)

En ese cuadro tambien hay unos numeros... Ahora, bajen el dedo a la letra "D", la "D".

(PAUSA :04)

En ese cuadro hay una raya.

(PAUSA :04)

Bueno ninos, ya estamos listos para trabajar. Recuerden que no deben hablar. Tienen que trabajar en silencio. No miren las hojas de respuesta de sus companeros...

Ahora, tomen sus lapices y preparense para escribir.
(PAUSA :04)

Cada uno de ustedes va a hacer su trabajo solito. No miren las hojas de respuesta de sus companeros. Guarden silencio y escuchen bien.

Volvamos al primer cuadro.
Busquen la letra "A" otra vez.
Pongan el dedo en la letra "A".

(PAUSA :04)

En ese cuadro hay dos rayas. Sobre la primera raya hay un numero. Piensen en el numero que va despues de ese. Sobre la otra raya escriban el numero que va despues.

(PAUSA :35)

Ahora, bajen el dedo a la letra "B", la "B".

(PAUSA :04)

En ese cuadro hay una raya para escribir la respuesta. Debajo de la raya hay unos porotos. En silencio, cuenten los porotos. Escriban el numero sobre la raya.

(PAUSA :50)

Bajen el dedo a la letra "C", la "C".

(PAUSA :04)

En ese cuadro hay unos numeros.
Busquen el numero mayor. Con su lapiz encierren en un circulo el numero mayor.

(PAUSA :20)

Bajen el dedo a la letra "CH", la "CH".

(PAUSA :04)

En ese cuadro tambien hay unos numeros. Busquen el numero doscientos cuarentiuno...
Encierren en un circulo el numero doscientos cuarentiuno.

(PAUSA :20)

Bajen el dedo a la letra "D", la "D".

(PAUSA :04)

Ahi hay una raya. Sobre la raya, escriban el numero doscientos treintisiete, el doscientos treintisiete.

(PAUSA :20)

Volvamos a la parte de arriba.
Ahora, vamos a la otra columna.
Busquen la letra "E". Pongan el dedo en la "E".

(PAUSA :04)

En ese cuadro hay una fila de soldados. Busquen el octavo soldado. Encierren en un circulo el octavo soldado.

(PAUSA :25)

Bajen el dedo a la letra "F", la "F".

(PAUSA :04)

En ese cuadro hay un ejercicio que ustedes deben hacer solitos. En silencio, lean el ejercicio y escriban la respuesta.

(PAUSA :40)

Bajen el dedo a la letra "G", la "G".

(PAUSA :04)

Ahi hay unos cuadrados divididos en partes. Busquen el cuadrado que esta dividido en medios.
Encierren en un circulo el que esta dividido en medios.

(PAUSA :20)

Bajen el dedo a la letra "H", la "H".

(PAUSA :04)

En ese cuadro hay otro ejercicio que ustedes deben hacer solitos. En silencio, lean el ejercicio y escriban la respuesta sobre la raya.

(PAUSA :45)

Bajen el dedo a la letra "I", la "I".

(PAUSA :04)

En ese cuadro hay un raya. Voy a leer un problema y ustedes piensien en silencio y escriban la respuesta sobre la raya. "Roberto llego a la escuela a las 8:00 y Luis llego dos horas mas tarde. A que hora llego Luis?" Escuchen. Voy a repetir. "Roberto llego a la escuela a las 8:00 y Luis llego dos horas mas tarde. A que hora llego Luis?" Escriban la respuesta sobre la raya.

(PAUSA :45)

Bajen el dedo a la letra "J", la "J".

(PAUSA :04)

Ahi hay un ejercicio que ustedes deben hacer solitos. En silencio resuelvan el ejercicio. Escriban la respuesta.

(PAUSA :50)

Ahora, vamos a descansar un minuto.
Denle vuelta a la hoja de respuesta.
Pongan sus lapices sobre la mesa y no los vuelvan a tocar.

(MUSICA 1:00)

Ninos, ya descansamos. Ahora estamos listos para continuar. Vamos a trabajar en la segunda cara, que es la que tiene un pajaro en la parte de arriba.

(PAUSA :04)

Tomen sus lapices y preparense.

(PAUSA :04)

Debajo del pajaro busquen la letra "K". Pongan el dedo en la letra "K".

(PAUSA :04)

En ese cuadro hay una raya para escribir la respuesta. Escuchen: piensen en silencio cuanto es ochocientos mas veinticinco. Escriban solamente la respuesta de ochocientos mas veinticinco.

(PAUSA :30)

Bajen el dedo a la letra "L", la "L".

(PAUSA :04)

Ustedes deben hacer ese ejercicio por si solos. Lean el ejercicio en silencio y escriban la respuesta sobre la raya.

(PAUSA :45)

Bajen el dedo a la letra "LL", la "LL".

(PAUSA :04)

En ese cuadro hay una raya. Sobre esa raya escriban la respuesta, solamente la respuesta de setenta menos sesenta, setenta menos sesenta.

(PAUSA :30)

Bajen el dedo a la letra "M", la "M".

(PAUSA :04)

En ese cuadro hay un ejercicio que ustedes deben hacer solitos. En silencio lean el ejercicio y escriban la respuesta.

(PAUSA :50)

Bajen el dedo a la letra "N", la "N".

(PAUSA :04)

Ahi hay una raya. Sobre esa raya escriban solamente la respuesta de dos por tres, dos por tres.

(PAUSA :25)

Bajen el dedo a la letra "N", la "N".

(PAUSA :04)

Hagan ese ejercicio solos.
Escriban la respuesta.

(PAUSA :50)

Bajen el dedo a la letra "O", la "O".

(PAUSA :04)

En ese cuadro hay unas palabras. La primera es mes. La segunda palabra es dia. La otra palabra es ano. Piensen en silencio cual significa mas tiempo, un mes, un dia, o un ano. Encierren en un circulo la palabra que significa mas tiempo.

(PAUSA :20)

Volvamos a la parte de arriba.
Ahora vamos a la otra columna.
Busquen la letra "P". Pongan el dedo en la "P".

(PAUSA :04)

En ese cuadro hay un ejercicio.
En silencio, hagan el ejercicio y escriban la respuesta.

(PAUSA :50)

Bajen el dedo a la letra "Q", la "Q".

(PAUSA :04)

En ese cuadro hay una raya.
Sobre esa raya escriban cuantos centimetros tiene un metro, cuantos centimetros tiene un metro.

(PAUSA :25)

Bajen el dedo a la letra "R", la "R".

(PAUSA :04)

En ese cuadro hay un ejercicio que ustedes deben hacer solitos.
Resuelvan el ejercicio y escriban la respuesta.

(PAUSA :50)

Bajen el dedo a la letra "S", la "S".

(PAUSA :04)

En ese cuadro hay una raya. Voy a leer un problema y ustedes escribiran la respuesta sobre la raya. Escuchen: "Con diez bolivianos Don Jose va a comprar platanos. los platanos que el quiere valen tres bolivianos. Piensen, sin decir nada, cuantos bolivianos le van a dar de vuelto." Escuchen. Voy a repetir: "Con diez bolivianos Don Jose va a comprar platanos. Los platanos que el quiere valen tres bolivianos. Escriban sobre la raya cuantos bolivianos le van a dar de vuelto."

(PAUSA :30)

Bajen el dedo a la letra "T", la "T".

(PAUSA :04)

Voy a leer un problema y ustedes van a encerrar la respuesta correcta. Escuchen: "La madre de Jose hizo 12 galletas. Jose se comio 5. Cuantas galletas quedan?"
Escuchen. Voy a repetir: "La madre de Jose hizo 12 galletas. Jose se comio 5. Encierren en un circulo el numero de galletas que quedan."

(PAUSA :30)

Bajen el dedo a la letra "U", la "U".

(PAUSA :04)

Voy a leer un problema y ustedes van a encerrar la respuesta correcta. Escuchen: "La Sra. Lopez vendio cuatro pollos a tres bolivianos cada uno. Piensen cuanto gano la senora por todo." Escuchen. Voy a repetir. "La Sra. Lopez vendio cuatro pollos a tres bolivianos cada uno. Encierren en un circulo cuantos bolivianos gano ella por todo."

(PAUSA :30)

Bajen el dedo a la letra "V", la "V".

(PAUSA :04)

En ese cuadro hay una raya. Yo voy a leer un problema y ustedes piensen en silencio y escriban la respuesta sobre esa raya. Escuchen: "Emilio comio 4 duraznos y mas tarde comio 3 mas. Carlos comio 5 duraznos. Cuantas comieron por todo?" Voy a repetir. Escuchen: "Emilio comio 4 duraznos y mas tarde comio 3 mas. Carlos comio 5 duraznos. Cuantas comieron por todo?" Escriban la respuesta sobre la raya.

(PAUSA 2:00)

Hasta aqui llegamos. Hemos terminado. Ha sido un placer trabajar con ustedes. Hasta pronto.