DOCUMENT RESUME

ED 371 715 IR 016 629

| | |
|---|---|
| AUTHOR | Moulton, Jeanne |
| TITLE | Interactive Radio Instruction: Broadening the Definition. LearnTech Case Study Series No. 1. |
| INSTITUTION | Education Development Center, Inc., Newton, Mass. |
| SPONS AGENCY | Agency for International Development (IDCA), Washington, DC. Bureau for Research and Development. |
| PUB DATE | Jan 94 |
| CONTRACT | DPE-5818-C-00-0046 |
| NOTE | 45p. |
| PUB TYPE | Reports - Evaluative/Feasibility (142) |
| EDRS PRICE | MF01/PC02 Plus Postage. |
| DESCRIPTORS | Academic Achievement; Cognitive Processes; Constructivism (Learning); Cooperation; *Developing Nations; *Distance Education; Educational Change; *Educational Radio; Educational Technology; Elementary Secondary Education; Foreign Countries; Interaction; International Programs; Learning Theories; Partnerships in Education; Program Development; *Teacher Role; *Technological Advancement; Telecommunications |
| IDENTIFIERS | Costa Rica; Dominican Republic; Honduras; *Interactive Radio; Kenya; Nepal; Nicaragua; Papua New Guinea; *Radio Mathematics Project; South Africa |

ABSTRACT

Interactive radio instruction has gained attention as a low-cost means of improving the academic achievement of primary school students. The Radio Mathematics Project in Nicaragua and subsequent programs developed by the Learning Technologies for Basic Education (LearnTech) Project illustrate the evolution such programs have undergone as technology and society have changed. The term "interactivity," was used to characterize the simulated conversation of radio broadcasts in which students responded in chorus to questions posed by the radio teacher, but the concept has expanded. Programs started after Radio Mathematics, which was initiated in 1974, have presented new and different challenges. Concepts being taught are more complex, students are expected to apply what they learn outside the classroom, and classroom teachers have a more important role. Such programs as Radio Science, which is taught in Papua New Guinea, have employed new cognitive-learning theories. A new radio program based on constructivist principles is being used in South Africa. Radio projects have pioneered interactive instruction and remain in the vanguard of the application of learning theory to education in the developing countries. (Contains 20 references.) (SLD)

# INTERACTIVE RADIO INSTRUCTION: BROADENING THE DEFINITION

## *LearnTech Case Study Series No. 1*

*by Jeanne Moulton*
*January 1994*





LearnTech

*photo credits:*

*cover: Andrea Bosch*
*page 9: Frank Watson*
*page 12: Michelle Fryer*
*page 17: Frank Watson*
*page 21: Tom Tilson*
*page 26: Michelle Fryer*
*page 30: Pornjit Arunyakanon*
*page 36: Linda McKenna*

*A project of the Learning Technologies for Basic Education project, the Education Development Center and the Office of Education, Bureau for Research and Development, United States Agency for International Development. This document was directed by the Education Development Center and funded by the United States Agency for International Development, Bureau for Research and Development, Office of Education under contract DPE-5818-C-00-0046.*

## *Acknowledgements*

The following people who have worked on interactive radio instruction projects sponsored by the U.S. Agency for International Development contributed greatly to this paper by allowing me to interview them and by sharing relevant documents: Dolores Alvino, Steve Anzalone, Barbara Butterworth, Carleton Corrales, Esta de Fossard, David Edgerton, Jamesine Friend, Michelle Fryer, Klaus Galda, Maurice Imhoff, Linda McKenna, Dean Nielson, Tom Roy, Tom Tilson, Frank Watson, King Beach and Barbara Scott Nelson. In addition to many of these same people, others provided excellent feedback through discussion of these ideas and reading early drafts: Andrea Bosch, Jim Hoxeng, and Michael Laflin. James M. Royer at the University of Massachusetts was of considerable help in developing the section on cognitive learning theory.

I want to thank each of these people for their time and effort, and I especially want to thank Michael Laflin for the opportunity to do this work and for his support during the process.

## *Table of Contents*

# *Introduction*

Interactive Radio Instruction has gained worldwide attention as a low-cost means of improving primary school students' academic achievement. This instruction, effective in a wide range of schools, is particularly beneficial in schools with poorly trained teachers and few additional resources. Yet the "interactive" character of this strategy has taken new forms as new programs have been designed in different subject areas, for different groups of students, and using different media.

In the Radio Mathematics program introduced in Nicaragua in 1974, interactivity was characterized as a "conversation" between the radio teacher and the students. The radio teacher posed questions to which students responded in chorus at a rapid pace. Since then, interactive radio instruction has been used to teach children and adults basic language and science, to instruct them in good health practices, to promote environmental protection, and to train teachers.

At each stage of its adaptation from one use to another, program designers have faced different kinds of learning objectives, resulting in new challenges. They have encountered limitations in equating "interactivity" with "conversation."

- While many questions in basic math have only one correct answer (two plus two is four; three times four is twelve), even simple questions in language arts are likely to have more than one right answer ("What are you doing?" "I'm talking with you." "We're learning English."). The fast-paced conversation does not work as well in teaching language.

- Much instruction in basic math and language procedures focuses on teaching facts and procedures so they become automatic. Frequent drill and petition can help this learning process. But many s ct areas within science and social studies, as well as nd language, require that we encourage *inquiry* by asking questions that allow students more latitude in their answers. Typically, drill and practice do not seem appropriate in teaching inquiry and problem solving.

- In offering health and environmental education, we aim for changes in behavior outside of the classroom. Students' ability to respond to questions in class may not affect what they do at home.

It appears that we need to reexamine the usefulness of defining "interactivity" as simply a conversation, and look again at the value of interactivity in Radio Mathematics as well as in subsequent interactive radio instructional programs.

## *Guiding questions*

What have we learned from more recent uses of interactive radio instruction about the function and value of interactivity in radio teaching? How has the notion of interactivity evolved since Radio Mathematics in 1974?

The Learning Technologies for Basic Education (LearnTech) Project, which supports a wide range of interactive instructional programs, has raised these questions. In this paper, we will explore the evolution of the concept of interactivity and its applications in interactive radio instruction programs that have followed Radio Mathematics.

The availability of staff and other resources, as well as political and logistical considerations, impinges heavily on the ability of any interactive radio instruction project to succeed. But they do not diminish the importance of the conceptual aspect of the curriculum and instructional methods. Therefore, it is important to take note of the progress that has been made in the course of interactive radio instruction and in broader education theory.

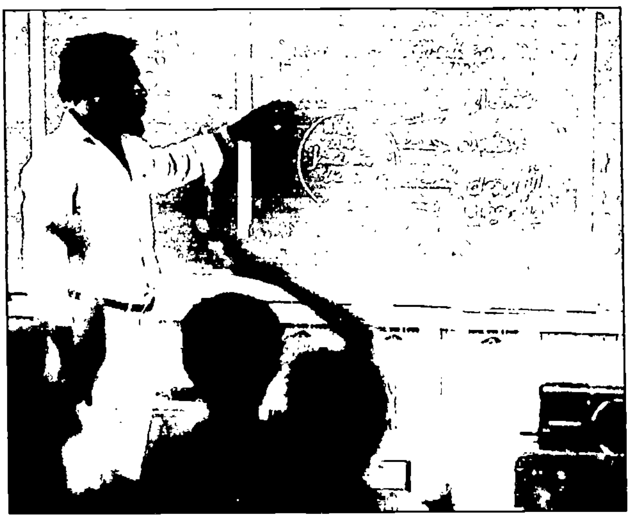
We will look beyond our own experience with interactive radio instruction for a better understanding of the function and value of interactivity. Dramatic progress has been made over the past two decades in distance education and in learning theory. What have we learned from these developments that can guide us in a broader view of interactivity?

We will look first at how interactivity has been defined for various instructional purposes and bring our own definition of interactivity up to date. Then we will briefly survey a selection of interactive radio instruction projects to learn how the use of interactivity has evolved since 1974. Following this survey, we will review aspects of current learning theory that apply to LearnTech projects. Finally, we will sugg;st guidelines for the development of interactive instruction based on recent experience and recent learning theory.

## *Defining "Interactivity"*

The designers of Radio Mathematics employed "determinants of effective learning" that they had derived from the behavioral and associationist learning theories that were the basis of their work in computer-aided instruction[1]:

- Students learn best from the tasks they do (active learning).
- Students learn best by practicing new skills in short lessons over days, weeks, or months (distributive learning).
- The instructional design must be rigorous, its development guided by intensive formative evaluation.



***Active learning eventually became the key characteristic of interactive radio instruction.***

- Correct student responses must be reinforced immediately[2].

The first of these, active learning, eventually became the key characteristic of interactive radio instruction. The active learning principle was implemented by designing radio programs that mimicked a conversation between classroom students and the radio teacher. In these "conversations," the teacher would ask a question, students would respond in chorus, and the teacher would announce the correct answer, thus providing reinforcement. Program designers aimed to have students respond to the radio teacher at least once every 25 seconds. This teaching strategy, which stood in sharp contrast to other uses of radio for instruction, was eventually coined "interactive radio instruction."

But of course such instruction is not truly interactive. Interactive instruction in its purest, and perhaps most effective, form takes place when the teacher instructs the student through a dialogue based on the teacher's understanding of the knowledge being taught and of the student's effort to learn. In such a dialogue—the dialogues between Socrates and his students being the prime example—the teacher and the students learn from one another[3].

Many of those who are creating the tools and methods of distance education hold that the teacher need not be a person, and, indeed, much of the development of distance learning, particularly computer-aided instruction, aims to replace the teacher with a machine or another medium or combination of media. Likewise, this dialogue need not be between one teacher and one student, and much of the science of teaching aims to help the teacher engage in dialogue with an entire classroom of students.

It is from these two general attempts to adapt a truly interactive instructional dialogue that we begin to clarify our definition of interactivity.

## *Interactivity as a distance learning technology*

We look first at the role of interactivity in distance learning, in which the teacher and the students are separated by distances large enough to require some form of mediating technologies--radio, television, printed materials, or computers. Since the time of Radio Mathematics, the gap has grown much wider between media used in developing countries--mainly radio and printed materials--and media used in industrial countries, where computer technology has advanced to the point at which educators can conceive of using artificial intelligence machines as teaching aids that, like Socrates, can learn from their students as well as teach them.

But all distance learning technologies still simulate true interaction. The degree of sophistication with which a technology does this depends on:

- how well it simulates the nature of the tasks to be learned;
- how thoroughly and accurately it structures and sequences the tasks entailed in acquiring the knowledge it is presenting; and
- how readily it adapts to the student's approach to and progress in learning (corrects errors, selects a path based on how much the student knows and the procedures the student uses in acquiring the skills and knowledge).[4]

At the low end of this spectrum, for example, we might have a single written page on auto maintenance with which the student's only interaction is to read it. The student may learn nothing because the page hardly resembles the practice of fixing a car, it cannot hold the detail required for a thorough description of every aspect of auto maintenance, and it does not allow the student to learn by guided trial and error. At the other end, we might have a talking robot, competent in auto maintenance, who works side by side with the student as he maintains and repairs a car.

In between, we have a variety of media capable of simulating some form of interactivity. Interactive radio, as it is being used in LearnTech projects, is clearly a more advanced interactive technology than the single written page, but falls far short of the robot.

- The extent to which radio instruction can simulate the tasks being taught depends on the nature of the tasks--basic math procedures are easier to simulate than a diagnosis and treatment of intestinal disease.

- The success of radio instruction in structuring and sequencing tasks depends on the resources and skill of the program designers.

- In adapting to the student, radio is at a great disadvantage, because it is difficult to react to a student response with more than one option. Even the most primitive computer program or two-way radio system can do this. Radio's success in providing meaningful reinforcement or explanation depends on how well the instructional designers predict student responses.

In sum, in terms of distance learning technology, radio is a limited interactive medium: it can pose questions (or solicit responses), but it can only simulate reactions to the responses. Furthermore, like all distance learning media, radio is limited in the extent to which it can adapt its reactions to students' responses.

The *value* of interactive radio in instruction is *not* in its ability to

*Radio's success depends on how well the instructional designers predict student responses.*

engage in conversation (for this is it is only a weak imitation), but in its ability to promote active learning. Active learning—not conversation—is the principle on which Radio Mathematics was constructed. The conversation format is only one form of active learning. Radio can also help students learn from active engagement with other *people*—their peers, families, community members as well as their teacher—and from *things* such as what is brought into the classroom for demonstrations and what they find outside the classroom in their physical environment. We must maintain the broader definition of interactive radio as active learning if we are to make the most of its potential.

## *Interactivity in the classroom*

Just as there are technological limits to interactive instruction in distance learning, so are there practical limits to interactive instruction in the real world of schooling. Few people have the luxury of learning to think from a teacher like Socrates among a small group on a hillside near Athens. Students in much of the world spend their learning time in a crowded classroom, behind a desk, with one teacher. Even in schools rich in resources, the classroom is the primary learning environment for formal education.

The interactive instruction that takes place between the teacher and students in the classroom is in the form of either lecture, small group discussions, individual instruction, or what is sometimes called "recitation"—a repeated chain of events in which

- the teacher provides a structure, formulating the topic or issue;
- the teacher solicits a response or asks a question of students;
- a student responds to the question; and
- the teacher reacts to the students' answer.

And the chain of events is repeated[5].

A good teacher will formulate questions according to a logic, sequence and style based on an understanding of the structure of the knowledge to be acquired. A good teacher will also anticipate students' responses and the thinking behind those responses and move the dialogue forward in those terms toward the instructional goal.

Recitation is the form of instruction used in most of LearnTech's interactive radio instruction. The radio plays the role of teacher, providing the structure, asking questions, and giving the appearance of reacting to students' answers while moving the dialogue forward toward the instructional goal. The *value* of this form of interactivity lies in part in the teacher's ability to guide the dialogue with a large group of students.

### *A new definition*

With these views of interactivity from the perspectives of distance learning and classroom instruction, we can highlight the value of interactivity in instructional media: Interactivity

- can engage the students in active learning; and
- can facilitate a repeated sequence of instructions or questions and responses that moves the students toward the instructional goals.

This definition, which is more fundamental than "conversation," allows us to widen the variety of formats for interactive radio programming.

## *The Evolution of Interactivity in Instructional Radio*

In this section we will briefly trace the characteristics of interactivity that have evolved in interactive radio projects during the two decades since Radio Mathematics was introduced.

### *The evolution of interactivity from subject to subject*

**Radio Mathematics** was conceived initially at Stanford University by professionals who had done extensive research in computer-aided instruction. Their approach to teaching math by radio was to adapt computer-student interaction to a radio-students interaction. Thus, they transformed an individualized instruction format into a mass media format, incorporating the guiding principles of active learning, distributed learning, rigorous design, and reinforcement.

Working in Nicaragua and using the Nicaraguan syllabus for math in grades one through four, the Stanford team developed a curriculum based on a series of detailed and strictly sequenced instructional objectives. The team believed that basic math was readily amenable to this approach to instruction. The order in which concepts and operations are presented is almost universally agreed on, and the scope and sequence of instruction can be relatively easily transformed into building blocks of knowledge and skills.

Moreover, mastery of basic math requires extensive drill and practice in simple procedures. Just as drill and repetitive practice are a natural for computer-based instruction, they were readily adaptable to interactions between a radio teacher and the students, who could ask questions each of which had only one correct answer (and a class of students). Thus, the radio could simulate dialogue that actively engaged the students in learning.

Interactivity in Radio Mathematics was thus characterized by a rapid exchange of questions and answers between the radio teacher and students, who responded sometimes in chorus and sometimes individually by writing down their answer. During a 25-minute lesson, students responded about every 25 seconds. The lessons also distributed learning segments over successive days rather than teaching them in long blocks.

The success of this pilot project in math led to subsequent pilot projects in language arts and in science.

**Radio Language Arts.** The Radio Language Arts Program (RLAP) introduced in Kenya in 1980 to teach English to students in grades one through three stayed close to the model developed by the team in Nicaragua. The principles of language instruction at that time included reliance on the aural-oral (listening-speaking) method, which, like basic math, called for extensive drill and practice of sounds, words, phrases, and sentences. Like those of Radio Mathematics, Radio Language Arts lessons included rapid-paced conversations in English between the radio teacher and students in chorus.

But language instruction differs significantly from math instruction. The programmers pointed out that "it was quite difficult to articulate a language curriculum with the precision necessary for an effective, media-based instructional system. English is not as readily organized into a neat hierarchy of categories appropriate to a subject such as math."[6] The program designers on the Kenya team needed to be inventive and to adapt the format of interactivity to the inherent nature of language learning.

First, to help children engage in the English lessons, the program designers used the radio to create an illusion of an invented world of interesting characters with whom the students could interact. Rather than having the radio imitate the classroom teacher, they used radio as a "door" to a world of fantasy characters in which English was spoken.

This was a new concept of interactivity. Although Radio Mathematics had tried to use short stories and dramas as a means of getting students' attention, these did not work as well as rapid dialogue and paper and pencil activities. But in language instruction, the stories and fantasies created by the radio characters became integral to the language lessons and were able to engage the students in active learning. These dramas were designed on the principles that guide good scriptwriters in radio broadcasts: Variety, pace, plot and character, tension and resolution, and the arousal and satisfaction of curiosity.[7]

Second, although Radio Mathematics had used games and songs to provide a break from more intensive mental activities, these had little instructional content. Radio Language Arts, in contrast, used the language dimension of games and songs to actively involve students in learning.

Finally, the Kenya program took the first steps towards involving the classroom teacher in the radio lesson. For the practical reason that many teachers in Nicaragua had multi-grade classrooms and needed to devote their attention to students in other grades during the radio broadcasts, Radio Mathematics was designed so that once the teacher had turned on the radio, she was not required to help with the radio lesson. Language instruction, however, soon reaches a point at which a question has more than one correct answer, and the radio programmers found they could use the classroom teacher's help in soliciting answers from individual students. In the early lessons, as the broadcasts covered a variety of African-language areas, the radio also relied on the classroom teacher to give some instructions to students in their mother tongue. Fortunately, unlike teachers in Nicaragua, teachers in Kenya have only one grade at a time and thus were available during the radio broadcast. During some lessons segments, the radio gave classroom teachers a cue to call on an individual student to answer a question. The classroom teacher also prepared the chalk board for the day's lesson and helped to manage supplementary materials for reading and writing.

*Radio Science employed the radio as a coach or guide in demonstrations and experiments.*

So, altogether, interactive radio instruction in language looked less like computer-aided instruction than it did in math. The interactive character of the instruction took on new functions--as the door to a fantasy world, a leader of instructive songs and games, and a partner of the classroom teacher. Although the conversation format was not abandoned, it was varied to use individual students as well as chorus responses.

Radio Science. Radio Mathematics started with a computer-based instruction methodology and used the radio to conduct rapid-paced short-answer dialogues with the students. Radio Language Arts stemmed from the aural-oral methodology and, without abandoning conversation, also used the radio as a "door" to a world in which English was spoken. Radio Science was modeled on the "hands-on" methodology of teaching science, and, in addition to conversation and door uses, employed radio as a coach or guide in demonstrations and experiments.

While the first bits of skill and knowledge taught in both Radio Mathematics and Radio Language Arts were factual and relied on methods of drill and practice, the designers of Radio Science, following conventional science teaching methods, wanted to move much sooner in the curriculum to problem solving and conceptual knowledge. They wanted students to learn to observe, experiment, and discover what happens in the physical world and why it happens. They placed greater emphasis on open-ended questions and the development of inquiry skills.[8] Both the dialogue and the door mode of interactive radio instruction appeared to be sharply limited in their usefulness in teaching problem solving skills in science.

Although both Radio Mathematics and Radio Language Arts had to be sensitive to the cultural context in which they were implemented, Radio Science had to resolve issues of cultural congruity that were less explicit and more complex than they were in either Radio Mathematics or Radio Language Arts. Science requires that the learner resolve conflicts between her individual experience of the world, which is culturally as well as physically bound, and scientific concepts and theories that often defy sensual experience.

The Ministry of Education in Papua New Guinea had directed the Radio Science staff to use inquiry and hands-on teaching methods. This immediately posed two challenges. The first was an instructional design problem of conducting a dialogue between the radio teacher and the students in which the teacher asked more open-ended questions and the students were given more latitude in how they expressed themselves. Not only could there be more than one right answer, as in Radio Language Arts, but these answers could take varying amounts of time to express because they entailed more thought and reflection.

The program designers met this challenge by developing a questioning technique that guided students in small increments through the problem-solving process. After each question, they provided a musical interlude of 30 to 45 seconds for students to think about answers to the question. After the interlude, the radio teacher either directed the classroom teacher to select one student to answer the question, directed the students to discuss their answers in pairs, or did not request any vocal response. Then the radio teacher returned and said, "You *may have* answered..." followed by several appropriate answers to the questions and a brief discussion of why those were the correct answers.[9]

The second challenge was to provide opportunities for the students to conduct hands-on activities. The most trying component of this challenge was making the materials available. During the duration of Radio Science, its developers abandoned the effort to provide schools with standard science kits, because the materials in those kits, such as mirrors, had value outside of the science classroom and soon disappeared. Eventually they helped teachers build their own science kits from materials found in their own environment, such as fish-tin bottoms that could be used as mirrors, and assorted pebbles that could be used both in classification exercises and as weights in measuring exercises[10].

The other component of the hands-on challenge was to guide students through activities and help them understand the phenomena. To do this, the radio program used several techniques: Sometimes the radio teachers gave instructions directly to the children; sometimes they instructed the classroom teacher in how to demonstrate materials, and sometimes they helped the classroom teacher give step-by-step instructions to the students. Sometimes a "dry lab" was conducted in which the radio characters--teachers and students--participated in the activities during the broadcast lesson. Following the broadcast, classroom teachers helped their own students repeat the activity using the materials at hand.

Because most students in grades four to six science classes would terminate their formal education at the end of sixth grade, the Radio Science staff believed it was just as important to teach applied science as to teach basic concepts. Many lessons featured applications with which the students had actual experience, such as compost, litter, and soils.

In the Radio Science project, although the program designers were able to maintain the principle of active learning, they found the principle of distributive learning to be more troublesome. Lesson segments that dealt with hands-on activities took time, and they found that they had little time left to review concepts from earlier lessons. Moreover, concepts in science could not be reviewed as quickly and efficiently as subtraction problems or vocabulary words.

Like Radio Language Arts, Radio Science increasingly involved the teacher in the radio lessons and pre- and post-broadcast activities. The teacher was indispensable in helping to provide materials for hands-on activities and to manage those activities in the post-broadcast sessions. The teacher's help was also needed in directing students to answer questions posed by the radio characters, and they were often asked to make some preparations before the lesson in order to facilitate students' responses. For example, teachers were asked to assign students to write answers on the chalk board during the musical interlude.

Eventually the program designers began broadcasting supplementary help for teachers. Twice a week in the evening, special lessons were broadcast for teachers to help them prepare for the next day's lessons. These broadcasts seemed to be popular, and anecdotal evidence shows that some teachers taped them and replayed them in preparation for the next day.

Because of other demands on AID resources, funds for the Radio Science pilot project were cut severely in 1989. The program staff did not have adequate resources to develop to their own satisfaction a complete science curriculum that guided teachers in hands-on activities or in using the open-ended questioning techniques that had been introduced so successfully. In addition, the good start toward increasing support for teachers in the presentation of interactive radio instruction did not lead to a well tested methodology for this kind of teacher training. It was not well documented or publicized for use in other radio projects. The new uses of interactivity that Radio Science was exploring were dropped.

**Radio Health.** In 1987 Radio Mathematics was introduced in Bolivia with few changes from the Nicaragua program. After two successful years, the LearnTech team began to develop a program in health for third through sixth graders with the expectation that these young students would apply and share what they learned at home. The use of interactivity in Radio Health closely followed the model of Radio Mathematics, even though in many respects the problem-solving nature of instruction in health more resembles that of science than of math. The radio characters asked the students a rapid series of questions each of which had a single

*Radio Health programs also used songs, games, and role playing.*

correct answer. Different from Radio Mathematics though, these questions usually followed three- to four-minute stories that dramatically illustrated the messages. The programs also used songs, games, and role playing.[11]

Because health practices are intimately tied into people's connection to their cultural and physical world, the Radio Health team needed precise and in-depth information about the people's knowledge, attitudes, and practices related to the health behaviors they intended to teach. Radio Health greatly expanded the preliminary research on the radio audience and formative evaluation that guided them in designing lessons in health education.

At first, the Radio Health team put aside the distributive learning principle adhered to in Radio Mathematics and designed the curriculum in distinct modules, each module focusing on a distinct health behavior such as ways of purifying water. Later, however, they revised the curriculum to become a single large unit. Because the programs were broadcast only once a week (in contrast to Radio Mathematics, which came on every day), the health team had less time to review content in the Radio Mathematics manner of distributed learning. Nonetheless, the new, single unit format allowed them to review earlier lessons from time to time.

As the summative evaluation of the Radio Health program has not yet been completed, it is too soon to know whether the program has met its goals for instruction in the classroom. Nor do we know the extent to which students have applied what they learned in the classroom to their health-related behaviors at home.

Radio for Environmental Education. In 1991 a project began in Costa Rica that uses radio to teach the national curriculum on the fourth and fifth grade levels in environmental education. Although it follows the interactive radio instructional programs that we have discussed, the Costa Rica program has some striking differences.

First, the program aims not only to teach basic ecological *concepts* in a systematic way (cognitive learning), but also to instill a positive *attitude* toward nature, and to stimulate *action* by means of community organization. Next, toward these ends, the project broadcasts not only to children in school but also to parents and other community members outside of school. Finally, the radio broadcasts do not "look and sound like" the interactive conversations of earlier radio math and language arts programs.

The projects in science, health, and environmental education have some notable similarities and differences in their interactive formats. Like Radio Health, Radio Environmental Education has attitude and behavior change, as well as cognitive learning, as objectives. But unlike Radio Health, the Costa Rica broadcasts do not stick closely to the conversation format. Instead, they encourage active learning by means of participation in real-life rather than classroom activities. As did Radio Science, the environmental education project attempts to convey concepts (What is an ecosystem?). But different from Radio Science, it offers hands-on activities outside of the classroom rather than within it.

In short, Radio Environmental Education in Costa Rica has departed substantially from the classic interactive radio instruction model. Some of its goals stand to be evaluated in different terms--attitudinal and behavioral change--rather than on its success in teaching cognitive skills. (The project has yet to undergo a summative evaluation, so we do not know how well its goals have been met.) At the same time, because the project endeavors to teach cognitive skills, the learning principles on which lessons are designed must be sound. The instructional designers need an expanded or modified set of principles that fit the new kinds of cognitive objectives they are teaching. We will see in the following section instructional principles that can be useful in this case[12].

## *Using radio for different audiences*

**RADECO.** As early as 1983, an interactive radio project was designed to reach children who had little or no access to school. RADECO, in the Dominican Republic, taught basic math and reading skills as well as some science and social studies, which were written into reading lessons. The curriculum was based directly on the national school curricula. Math lessons relied heavily on those developed in Radio Mathematics in Nicaragua, but reading lessons were created especially for RADECO.[13]

The innovations in RADECO were not so much in the design of the curriculum and radio instruction as in the setting in which they were broadcast. Following earlier experiences of Accion Cultural Popular (ACPO) in Colombia, where radio was used in a format that was not interactive to teach children and adults at home, RADECO created an infrastructure of modest shelters built by villagers which were used as learning centers. Children congregated at these centers late in the day, when they were free of chores. Radioauxiliaries, or paraprofessional teachers, distributed print materials to accompany the radio lesson, turned on the radio, and did what they could to help students follow the radio lesson. This group structure and learning environment seems to work well and to contribute to the project's success in meeting instructional goals.

**Basic education for adults in Honduras:** As recently as 1992, another interactive radio project has been initiated for out-of-school learners. In this case they are adults. The basic education interactive radio programs in Honduras teach math skills that are based on (1) the mental math program designed for school children in Honduras (see below), (2) reading and writing, based on radio lessons in language arts but modified for adults in Honduras, (3) civics and legal-democratic education, (4) family problems and values, and (5) population and its effects on health, economics, and the environment. Like RADECO, the project combines radio lessons, print material, and assistance from a radio-community monitor.

With its diverse curricula, some of which is clearly oriented to the real-life problems and decisions encountered by adults, this Honduras project faces some of the same challenges as do Radio Health and Radio Environmental Education. As an out-of-school program, it must deal with the same organizational issues as does RADECO.

**Teacher training.** Interactive radio programs have used two strategies to train teachers. One strategy, employed primarily as a means to meet the instructional goals set for *students*, is to involve classroom teachers in the radio lesson, by asking for their assistance in directing students' activities. Radio Language Arts used this strategy, and Radio Science took it further by modeling for teachers good questioning techniques and encouraging them to use those techniques on their own. Both of these programs, as well as most other interactive radio programs, have developed guides for teachers and supplemental broadcasts to aid them in using the broadcast and post-broadcast lessons.

The other strategy is to use interactive radio lessons for the primary purpose of training *teachers*. This was the strategy used in Nepal during the 1980s. To improve the skills of uncertified teachers, a series of teacher training programs (RETT II, and Radio Tuition) relied heavily on radio instruction but also used print materials and monthly sessions in which trainees met with experienced teachers. The programs were aimed at in-service teachers whose own primary education was incomplete or weak, and the curricula included both basic subject matter and pedagogical skills.

In addition to their target audience, the Nepal radio programs differed from earlier models in several ways:

- The programs themselves were less interactive; they consisted mainly of short lectures followed by a few questions that students were asked to answer.
- Trainees did not assemble to listen to radio lessons. Great

distances and varying schedules precluded such classes.

- Trainees were thus expected to tune into the radio broadcasts and work with the print materials each week on their own.

Unfortunately, the logistical difficulties that challenge every assistance effort in Nepal, combined with severe problems in developing an institutional base for the project, resulted in an immense chasm between program designs and their implementation.

Evaluations of these programs were only mildly positive,[14] and they probably cannot be considered a fair test of the use of interactive radio instruction for teacher training. Those working with the programs questioned whether trainees actually listened to the broadcasts on their own, and if they did, how strictly they paid attention[15]. Especially in the early years, the broadcast quality was poor, and the radio characters were not well developed. Plans for formative evaluation were severely compromised in implementation. As a result, it is difficult to identify contributions of the Nepal teacher training programs to interactive instruction.

More recently, interactive media—though not radio—have been used to train teachers in Indonesia and in Sri Lanka. Pilot programs in these countries are exploring the use of print materials, periodic contact sessions, and audio cassettes to train teachers in subject matter and pedagogy. The programs are aimed in particular at helping teachers present student-centered instruction and manage multi-grade classrooms.

The audio-cassette tapes introduce another new form of interactivity: Students are periodically directed to stop the tape and discuss answers to questions or problems posed with their peers and then to resume the tape, from which they receive comments on responses to questions.

Preliminary research has revealed that programs with more interactive sessions (contact sessions and written assignments that are graded and returned) are more effective than programs without these components.[13]

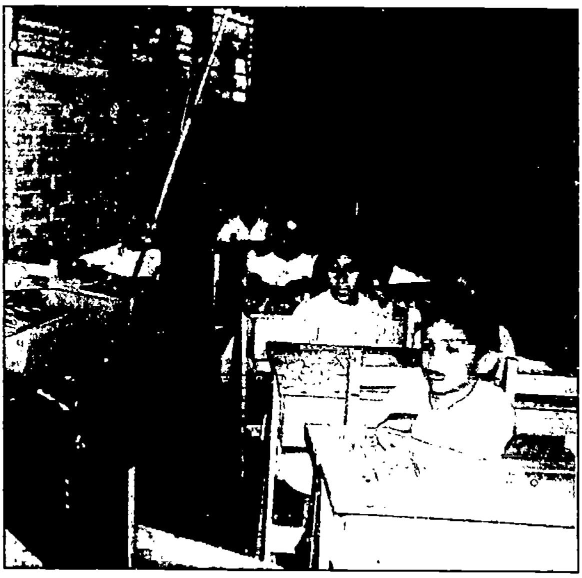
We have also learned more about using interactive radio instruction to train teachers through the progressive efforts of Radio Mathematics, Radio Language Arts, and Radio Science. In particular, it has become clear that teaching methods vary from subject to subject, and therefore teachers must be trained in methods relevant to particular subjects rather than in general methods that are not specific to subject matter.

### *The evolution of interactivity within subjects*

Math. The first interactive radio instructional program was designed specifically to teach basic math; it was not adapted from a program to teach another subject. A relatively large number of resources were allocated to create and test the program. For these reasons, among others, the program was successful and has been modified very little as it has been introduced in other countries. The exception is the Family of Numbers curriculum developed in Honduras in 1987 as a component of a comprehensive primary education reform project.

To resolve some practical issues, the radio team in Honduras agreed with the Ministry of Education to design a curriculum that teachers could use either with or without accompanying textbooks. This gave them an opportunity to focus on "mental math."

***Mental math programs aimed at giving children a better understanding of math concepts.***



While Radio Mathematics in Nicaragua taught children to solve math problems using paper and pencil algorithms, the Family of Numbers taught mental algorithms. It also aimed at giving children a better understanding of math concepts, which facilitated their transfer of skills to nonroutine problems. Although the conversation form of interactivity did not change, the new program succeeded in teaching students more about how to think through problems that involved math skills.

The Family of Numbers (the Honduras program) differs from Radio Mathematics (the Nicaragua program) in that it complements the math taught in textbooks rather than substituting for it. In addition, the Honduras program benefited from the experience of Radio Language Arts and Radio Science in providing a more active role for the teacher and in using a dramatic context for learning.

Most recently, a radical new approach to teaching math by radio is being discussed in South Africa. This approach is based on constructivist learning theory, which we discuss in the following sections.

**Language.** In the 1990s, a decade after Radio Language Arts in Kenya, LearnTech has developed new language courses. One is a Spanish language course for elementary school students in Guatemala whose mother tongues are Mayan languages. Another is an English language course for elementary school students in the townships of South Africa whose mother tongues are African languages. The approach to language teaching in these interactive radio programs has taken a dramatic departure from that used in Kenya.

In Guatemala the Spanish language program is not based on the fast-paced question and response pattern of the aural-oral method but on lessons that encourage students to struggle through utterances in a real-life context. Radio is not used as a mass language lab. Instead, the dramatic power of the medium is called to bring to life a context in which students can express their own thoughts and construct their own phrases[16]. The radio characters call on individual students to perform an activity in the classroom rather than asking for a chorus of responses. The radio teacher instructs students in how to interact with each other. Students' efforts are still reinforced by comments or follow-up questions, but student's responses are expected to vary.

In South Africa similar changes have been introduced. The aim of language teaching is to provide structured opportunities for students to construct their own messages and guide them in learning from these attempts and progressing to more complex and coherent messages. The new radio programs are 30 minutes long; they consist of 20 minutes of segments developed initially by Radio Kenya and 10 minutes of new segments. The latter are being created to incorporate recent theory on how people learn languages and to give the teacher a more active role in instruction. The program designers are attempting to make activities genuinely communicative by getting the students to communicate with each other[17]. This aim resembles the one in Guatemala and is based on the same principle: people learn languages through their efforts to communicate with others.

The main feature of the teacher's new role in the South African project is to manage students' interactions with each other. The radio teacher guides the classroom teacher in managing. Using the radio to interact with the teacher at the same time the teacher interacts with his students is the same use to which radio was being put in Radio Science when that project terminated. The Spanish language program in Guatemala is also giving the classroom teacher a more important role in instruction.

## *Trends in recent uses of interactivity*

In summary, while the classic model of Radio Mathematics in Nicaragua has taken hold in a number of countries, the past two decades have also seen notable changes in the use of interactive radio instruction.

- New subjects, new audiences, and new media are being used. Radio has been used to teach language, science, health, environmental studies, some civics, family life, pedagogy, and math. Learners include out-of-school children and adults, including teachers. Hands-on materials were introduced in Papua New Guinea; print materials have played a more important role and audio cassettes have been introduced in Indonesia.

- More complex concepts in math, science, and other subjects have been introduced that require the radio instruction to include open-ended questions; interaction with teachers, peers, and materials; and applications of learning in the classroom to situations outside of the classroom.

- Teachers often play a more important role in delivering the radio lesson.

Finally, the concept of interactivity has been expanded beyond the conversation format to include use of radio as a door to another learning environment, as a guide to activities that engage students in the learning materials, and as a facilitator of student-teacher and student-student interaction.

## *Contributions of cognitive learning theory*

During the two decades in which the uses of interactive radio instruction have been growing, dramatic advances have taken place in the field of learning theory and its application to instruction. Radio Mathematics was supported by principles of instruction that grew out of the dominant learning theories of the day--behavioral and associationist theories[18]. Learning was viewed as an "accumulation of pieces of knowledge and bits of skill [which] can be analyzed into hundreds of components to be placed in the learners' heads through practice and appropriate rewards."[19]

Behavioral and associationist theories have now been subsumed by cognitive learning theories, which often add insight to their foundations. Behavioral theory in particular was based entirely on learning that could be observed, and psychologists viewed the mind as a blank tablet onto which bits and pieces of knowledge could be inscribed. Cognitive theories place much greater emphasis on learning how the mind works, and from these models, they derive instructional principles.

### *Information-processing theory*

The cluster of information-processing theories received impetus from the popularity of computers and a fascination among learning theorists with how these mechanical minds process information. The following is a very brief overview of cognitive theorists' explanations of the structure and processes of the mind.[20]

- The mind is divided into two major structures: *long-term memory* and *working memory*. While long-term memory has an unlimited capacity to store information, working memory has a limited capacity and a limited duration.

- The mind stores two kinds of information: declarative and procedural. *Declarative memory* stores specific events, images, and verbal information—what are often called "facts." *Procedural memory* stores *strategies*, which are conscious plans for carrying out cognitive activities, and *procedures*, which are fast and complex routines or algorithms for accomplishing a task.

***A sound instructional design will include activities that help students learn, remember and think.***

The processes of the mind are learning, remembering and thinking.

- *Learning* is the process of adding to long-term memory.

- *Declarative learning* is moving information from working memory into long-term memory. *Procedural learning* is the process of transforming a deliberate, step-by-step processing activity into an automatic processing activity.

- *Remembering* is the process of activating a previously stored memory representation. The likelihood of remembering is governed by three events: the strength of the original memory trace, the length of time between initial learning and the recall, and the extent to which other learning interferes with initial learning.

- *Thinking* is the process of the mind learning from itself. Thinking involves solving problems, forming new concepts, and making decisions.

While behavorist and associationist theorists believe that thinking can be taught only after extensive learning had occurred, information-processing theorists believe that thinking, remembering, and learning can be taught simultaneously.

**Implications for instruction.** What are the general implications of this model of the mind for those who are designing interactive instruction?

A sound instructional design will include activities that help students learn, remember and think. It is not enough to add to the declarative and the procedural memory. Knowledge of a subject also requires that we apply what we have learned to solving new problems, forming new concepts, and making new decisions.

A related proposition of information-processing theory is that these three processes must be taught together *within a subject (or domain)*. Not only do "facts" and procedures of math vary from those of language, chemistry, and history, but so do the strategies for learning and the process of thinking. The more facts, procedures and strategies we know in a subject, the better able we are to think through a problem, to learn still more about the subject, and to apply our knowledge to situations not specifically taught to us.

These and other basic applications of information-processing theory to classroom instruction would not be disputed by many constructivist theorists. But before extending our discussion of applications, we will look at this second group of theories, many of which are substantially different from those of the information processors.

## *Constructivist theory*

Constructivist theories have two sources: the school of developmental psychology originated by Jean Piaget, and the "social constructivists" associated with the Russian, Lev Vygotsky. According to constructivists, knowledge is not transmitted from one who knows more to one who knows less, no matter how perfectly bits of knowledge are organized and sequenced. Rather, each individual constructs his or her own knowledge by interacting with the physical and social environment. Every individual's pathway to knowledge of each phenomenon is unique. Unlike computers, humans are not limited to representations of reality that have been provided to them. Humans experience their environment and they can create their own new representations of the way the world is.

While Piaget focused on how children constructed knowledge by interacting with their physical environment, Vygotsky studied how they learned through interaction with other people — peers as well as teachers. Even if we cannot "receive" knowledge in the same form and by the same means as another "transmits it," we do communicate with and learn from others. The media through which we communicate knowledge are words, numbers and other symbolic representations of our world. But these media are not natural and identical for all people in all places. They are artifacts of our cultural heritage, and thus we have the ability to change and modify them. This is essentially a social process in which participants construct new concepts—new knowledge—through interaction with others as well as from their physical environment.

The process of learning is the process of closing the gap between one's "spontaneous concepts" (those formed by means of his/her own everyday experience of the world) and "scientific concepts" (those developed through disciplinary knowledge). Vygotsky called this gap the "zone of proximal development."[21] It is the interval between what the learner knows independently and what knowledge he or she can acquire with assistance from an instructor or other more capable person, including a peer.

**Implications for instruction.** What does constructivist theory say about learning in the classroom? The knowledge that the learner acquires is not the same knowledge as that of the teacher. Before students can use the knowledge generated by others to interpret new situations, solve problems, think, reason, and learn, they must elaborate and question what they are told, examine the new information in relation to other information, and build their own new knowledge structures. Teachers are faced with the problem of helping students start to develop their own base of knowledge so they can learn independently later on.[22]

In order to learn, students need an environment that provides both stimuli to learn and tools and resources for learning. This rather stale observation takes on new meaning as we agree that students must construct their own knowledge. First, they must be motivated to acquire new thinking skills by having opportunities to use them. New knowledge comes only from the engagement of the student's own interest in something beyond her present understanding. Second, they must have the tools and often some guidance in using the tools to construct new knowledge. Since individuals follow different learning paths, a variety of stimuli and tools must be available.

Guidance can come from the teacher, whose knowledge of scientific concepts and ability to engage the student in dialogue can provide direction and alternative means to new constructs. Guidance can also come from students, who by sharing thoughts aloud while dealing with problems and challenges are able to influence each other's thinking processes.

## *The challenge for radio*

Both of the schools of cognitive theory—information-processing and constructivism—challenge the learning model of the teacher as "transmitter" and the student as "receiver," a model practically embodied in much of educational radio. Even though the principles of interactive radio instruction have, from the beginning, rejected a transmitter/receiver model, we need to take a fresh look at the nature of the interaction between the radio teacher and the classroom.

**Additional principles for designing instruction.** First, cognitive theory offers new guidance to curriculum writers of interactive radio instruction as we now know it. These build on the principles now used to engage students in active learning.

❖ *Teach strategies explicitly in subject contexts.*

It seems that one differentiation between fast learners and slow learners is the ability of the former to develop their own learning strategies and the difficulty the latter have in recognizing when to apply learning strategies they have been taught. Thus, since the majority of students are not fast learners, teachers should instruct students in specific learning strategies. Such strategies vary from subject to subject, and within subjects, from purpose to purpose. Moreover, different strategies work better with some learners than with others.

Some examples of learning strategies are (1) rehearsal, whereby the learner consciously repeats information over and over until it is learned; (2) means-ends analysis, whereby the student's steps toward solving a problem or reaching a conclusion are sequenced into minute explicitly detailed steps; and (3) fractionation, whereby a complex problem is separated into smaller, simpler parts.

Others might be called metastrategies, combinations of strategies into a routine method. Self-regulated reading, whereby the reader approaches a text with techniques for acquiring an overview, checking comprehension, and reading for a purpose is an example of a metastrategy. [23] Another example is the following steps involved in solving a difficult problem: (1) reading or listening to the problem, (2) analyzing it, (3) exploring likely solutions, (4) planning an approach, (5) implementing the approach, and (6) verifying the solution. People who have more mastery of a subject are more likely to devote the necessary time and attention to each of these steps. People with less mastery are more likely to shortchange the analysis and jump directly into implementing an attractive approach.

❖ *Help students to recognize their existing constructs and to* *modify these constructs with the acquisition of new information.*

In presenting new material, the classroom teacher is advised to enter into dialogue with the students as a means of finding out what they know and feel about the relevant concepts and information so that they can link the new material to existing knowledge. Because radio is a mass medium, it is impossible to design activities in which the teacher and students carry out such a dialogue in real time during the radio broadcast. This limitation can be overcome to some extent. First, formative research helps to substitute for in-class dialogues. Formative research has been used extensively in interactive radio instructional programs and has been critical in helping the instructional designers predict what constructs the students are using. In Radio Health, in which relevant constructs are heavily laden with culture-based knowledge, formative evaluation has been indispensable in designing instruction.

But no matter how certain the instructional designers are of what students' constructs are likely to be, they must build into the lesson opportunities for students to describe their constructs to the teachers or to their peers; in other words, to engage in some activity that supports them in formulating clearly what they think. As they did in Radio Science, the radio teacher can then suggest a range of constructs that, based on results of formative research, students are likely to have.

- *Provide meaningful links between new knowledge and real problems, concepts and decisions.*

The instructional designers of most interactive radio programs have recognized that most of their students would end their career in school after five or six years, and that, therefore, their basic skills should be developed with practical rather than academic applications in mind. Cognitive learning theory gives us another reason for linking lessons in the classroom to real-life situations: acquiring skills and strategies, no matter how good one becomes at them, does not make one a competent reader,

***Formative research has been critical in helping the instructional designers predict what learning constructs students use.***

writer, problem solver or thinker. The habit of using skills and strategies and the knowledge of when to apply them need to be developed. Throughout the course of instruction, students must be given occasions to stretch their understanding of their newly acquired knowledge through confrontation with meaningful problems to solve and decisions to make. The content of lessons must be chosen from among concepts that lend themselves to question and discussion because they are within the realm of experience of the students.[24]

This development in cognitive theory helps to justify the need for abundant reading materials available to new literates. It also demands that the instruction in the classroom be constantly linked to the learner's environment beyond the classroom, and that those links be made explicit.

❖ *Teach basic procedures to become automatic.*

Mastering a new skill, whether it be a physical skill like kicking a soccer ball or a cognitive skill like solving a subtraction problem, requires that we perform the basic procedures of that skill automatically. Thus, as the soccer ball approaches, we kick it where we want it to go without stopping to deliberately direct every muscle. When we subtract one number from another, we "borrow" without reciting the process we are going through with each pair of digits. To use an analogy from computers, we call upon "macros" to take us quickly through each step of the procedure. In school, we expect students to master basic procedures in math so that their limited working memory is not consumed with thinking about number and letter identification but instead is free to focus on comprehension and problem solving.

Each subject—science and social science as well as math and language—has its own procedures in which students need abundant practice to make them automatic.

**More radical adjustments.** While the principles just discussed can perhaps enrich the interactive radio lessons currently being developed, cognitive theory, particularly constructivist theory, suggests a radically new view of the classroom and role for the teacher. The classroom becomes a critical environment that can either foster or prevent learning, and the teacher's role becomes one of facilitating students' knowledge of their world, not transmitting information. How can interactive radio adjust to new insights into the nature of learning?

- *Guide students in working independently to think through tasks and problems.*

Cognitive theory teaches us that each student follows his or her own learning path. In this case, the radio teacher must rely less on direct instruction to the entire group of students and more on structuring opportunities to learn individually and with peers in small groups. Few, if any, students will have the advantage of a teacher who can converse with them individually in learning tasks, but the radio teacher can allow students more time to think through answers to questions and to take more time in discussing alternative approaches that individual students might be trying to use. The radio teacher can also engage the students in real tasks, such as writing letters to each other or recognizing real problems in their lives that require mathematical solutions. Because radio presents voices but not pictures, the radio can simulate the real world in a way that enlivens the students' imaginations and makes that simulated world their own.

❖ *Make use of the social dimensions of learning.*

If learning is a social activity, then the classroom should be a social environment that maximizes students' opportunities to learn not only from the teacher but from each other as well. According to constructivist theorists, when students talk to each other while confronting a task, they reveal to themselves and to others their thinking processes. Those that lead to success are then adopted by other students working together to think through problems; thinking becomes a social activity and one with social value.

❖ *Create a partnership between the radio teacher and the classroom teacher.*

An effective teacher needs to have some "scientific" conceptual knowledge of the subject matter as well as the skill to interact with students in ways that guide their thinking. Though many teachers in interactive classrooms lack these skills and knowledge, the radio teacher may be able to coach the classroom teacher as well as the students in activities that allow the classroom teacher to learn a coaching role while working with the students. The teacher's interaction with individuals, pairs or groups of students would allow students to engage in a social process with someone who knows more than they do on the subject. The radio teacher can guide in the selection and presentation of learning tasks and problems and might be able to help guide the classroom teacher in monitoring students' attempts at problem solving.

❖ *Help teachers and students assess what students have learned.*

Cognitive learning theory has thrown into question the conventional approach to assessing student achievement. Successful instruction results in improvements in students' thinking processes, not simply in their accumulation of facts and procedures Student assessment is an area in which even the most resourceful schools are struggling to improve. Though we cannot suggest how radio teachers might contribute to student assessment, this challenge should not be overlooked.

### *Current efforts to reform*

We mentioned that the language programs in both Guatemala and South Africa have departed from the model introduced in Kenya. Indeed, both have been strongly influenced by constructivist theory. In addition, educators in South Africa are in the early phases of designing interactive radio instruction in math based on constructivist theory. The experience of these teams will inform us of the practical challenges and solutions to developing curricula based on current cognitive learning theory.

## *Summary*

We have examined the concept of "interactivity" used in various LearnTech projects in order to see how the interactive radio instruction strategy has evolved since it was introduced in the Radio Mathematics program in Nicaragua in 1974. We have also turned to advances in learning theory since that time to see what light recent theories can shed on designing effective interactive instructional programs.

The term "interactivity" was used to characterize the simulated conversation of radio broadcasts in which students responded in chorus frequently to questions posed by the radio teacher. Subsequently, interactivity has included other formats as well. The value of interactive programs is their ability to (1) actively engage the students in learning, and (2) present highly structured lessons that allow the radio teacher to control the sequence and pace of learning activities. Although interactive radio instruction may not always "sound" like Radio Mathematics, it can be an effective course of instruction as long as it adheres to this broader definition of interactivity.

The forms of interactivity have changed because projects subsequent to Radio Mathematics have presented new and different challenges: materials require more latitude in students' responses, the concepts being taught are more complex, students are expected to apply what they have learned outside of the classroom, and teachers are given a more important role in delivering the lessons.

Recent advances in learning theory can offer guidance to adapting interactive radio instruction to meet these challenges. Cognitive learning theories focus on the structure and processes of the mind. They consider how learners create knowledge from merging currently held and new information.

Cognitive learning theory also offers new principles that can guide the development of interactive instruction in subjects like science and social studies as well as in math and language. Many of these principles apply to interactive radio as we know it now.

- Teach learning strategies explicitly in subject contexts.
- Help students to recognize their existing constructs and to modify those constructs with the acquisition of new information.
- Provide meaningful links between new knowledge and real problems, concepts, and decisions.
- Teach basic procedures to become automatic.

Others suggest more radical changes in conceptualizing the role of radio in the classroom.

- Guide students in working independently to think through tasks and problems.
- Make use of the social dimensions of learning.
- Create a partnership between the radio teacher and the classroom teacher.
- Help teachers and students assess what students have learned.

Recent interactive programs have made use of these guidelines.

Radio Science designed lessons that link students' real-life experience to concepts presented in classroom lessons. Radio Science, as well as teacher training programs using other interactive media, has explored using the role of the radio teacher in coaching the classroom teacher. More recently, radio language programs in Guatemala and South Africa have employed constructivist principles, which are designed to help students begin by constructing their own utterances rather than mimicking correct ones. A new radio program in math based on constructivist principles is being explored in South Africa. Finally, Radio Health has demonstrated how extensive preliminary research and formative evaluation can help to ensure that radio lessons engage students in challenging their own beliefs about health issues.

The programs that are currently being developed, based on recent cognitive learning theory, merit attention. In addition, the experience of Radio Science deserves to be reexamined in regard to the practical steps it took toward redefining interactivity. Finally, the role of radio in providing inservice coaching to classroom teachers warrants special consideration. We have moved away from Radio Math's motivation to remove the classroom teacher from the lesson. But we are far from understanding how the radio teacher and the classroom teacher can most efficiently work as partners in creating an effective learning environment.

The efforts being made to improve interactive radio instruction based on current learning theories are not insignificant. Educational reform is receiving much attention and far more resources these days than it has for many years. Yet few of these reforms have been able to contribute as directly to what goes on in the classroom as has interactive radio instruction. Those who are using the radio medium have opportunities to call on recent learning theory to affect directly the education of children in classrooms in the developing world. Radio projects have pioneered interactive instruction in these classrooms. It behooves them to take into account recent advances in knowledge of how people learn.

## *Endnotes*

1. USAID, *Interactive Radio Instruction: Confronting Crisis in Basic Education*, p. 12.

2. Clearinghouse on Development Communication, "Interactive Radio Instruction: Method and Design." Note that different lists of determinants or principles are stipulated in different documents.

3. Jonassen, David H., "Interactive Lesson Designs. A Taxonomy." p. 14.

4. Jonassen, *op. cit.*, p. 9.

5. Gage, N.L. and David C. Berliner, *Educational Psychology*, 4th ed., p. 259.

6. Imhoff, Maurice and Philip R. Christensen., eds., *Teaching English by Radio: Interactive Radio in Kenya*, p. 30.

7. Imhoff, *op. cit.*, p. 120.

8. Education Development Center, *Radio Science Project 1989-1990 Report*, p.2 and Frank Watson.

9. Radio Science final report, p. 17, and Frank Watson.

10. Tom Roy

11. Fryer, Michelle L., "Health Education through Interactive Radio: A Child-to-Child Project in Bolivia," p. 67.

12. Klaus Galda

13. RADECO

14. Holmes, Dwight R., John K. Mayo, and Dibya Man Karmacharya, "Training Teachers at a Distance: A Case Study of Nepal's Radio Education Project."

15. Barbara Butterworth

16. David Edgerton

17. Maurice Imhoff

18. Patrick Suppes and his associates at the Institute for Mathematical Studies in the Social Sciences at Stanford University, who originated Radio Math, were not strictly behaviorists. According to Philip Sedlak, who knew their work at Stanford and worked with the radio project in Kenya, Suppes and his colleagues were well versed in cognitive theory. Yet perhaps because of the nature of the radio medium, Radio Math has a strong stimulus-response character.

19. Resnick, Lauren B. and Leopold E. Klopfer, "Toward the Thinking Curriculum: An Overview," *Toward the Thinking Curriculum: Current Cognitive Research*, p. 2.

20. Royer, James M. and Robert S. Feldman, *Educational Psychology: Applications and Theory*, 2nd ed. (draft).

21. Prawat, Richard S., "The Value of Ideas: Problems Versus Possibilities in Learning, " *Educational Researcher*, August-September 1993, p. 5-16.

22. We must distinguish between three benefits of linking concepts taught in the classroom with practical applications of these lessons outside of the classroom. (1) Such application strengthen the learner's knowledge of the concept. This is the *pedagogical* value of practice that we have just discussed. (2) The applications ensure that the concept has immediate *practical* value; in Radio Science this was an important criteria because most students were not preparing for a long academic career. (3) The applications provide opportunity for *changing behavior*. Radio Health and Radio Environmental Education are aimed explicitly at changing behavior, this is not the immediate goal objective of instructional guidelines posed by the cognitive theorists. Other forces in addition to instruction are often required to effect behavior changes.

## *References*

Academy for Educational Development, "Adult Basic Education in Honduras: The Use of Interactive Radio Instruction for Adults." n.d.

Agency for International Development, *Interactive Radio Instruction: Confronting Crisis in Basic Education.* Washington, D.C., n.d.

Agency for International Development, *Radio-Assisted Community Basic Education (RADECO).* Pittsburgh, PA: Duquesne University Press, 1988.

Bransford, John D., and Nancy J. Vye, "A Perspective on Cognitive Research and Its Implications for Instruction," in Resnick, Lauren B., Leopold E. Klopfer, *Toward the Thinking Curriculum: Current Cognitive Research.* Washington, D.C.: Association for Supervision and Curriculum Development, 1989.

Cole, Michael, "Cognitive Development and Formal Schooling: The Evidence from Cross-Cultural Research," in Luis C., Moll, *Vygotsky and Education: Instructional Implications and Applications of Sociohistorical Psychology,* Cambridge: Cambridge University Press, 1990.

Education Development Center, *Radio Science Project 1989-1990 Report.* Newton, MA, n.d.

Education Development Center, *Radio Science Project Final Report.* Newton, MA, December 31, 1990.

Foote, Dennis, Jamesine Friend, Jeanne Moulton, and Jane Farola, "Evaluation of Mathematics Instruction by Radio in Honduras." Menlo Park, CA: Applied Communications Technology, 1991.

Friend, Jamesine, "Interactive Radio Instruction: Developing Instructional Methods," *British Journal of Educational Technology,* XX, 2, 1989.

Fryer, Michelle L., "Health Education through Interactive Radio: A child-to Child Project in Bolivia," *Health Education Quarterly,* XVIII, 1, Spring 1991.

Gage, N.L. and David C. Berliner, *Educational Psychology*, 4th ed. Boston: Houghton Mifflin Company, 1988.

Gagne, Robert M., Leslie J. Briggs and Walter W. Wagner, *Principles of Instructional Design*, 3rd ed. New York: Holt, Rinehart and Winston, 1988.

Galda, Klaus, "The Interactive Radio Environmental Education Project in Costa Rica." Report to Educational Development Corporation, December, 1992.

Gallimore, Ronald, and Roland Tharp, "Teaching Mind in Society: Teaching, Schooling, and Literate Discourse," in Luis D., Moll, *Vygotsky and Education: Instructional Implications and Applications of Sociohistorical Psychology*, Cambridge: Cambridge University Press, 1990.

Holmes, Dwight R., John K. Mayo, and Dibya Man Karmacharya, "Training Teachers at a Distance: A Case Study of Nepal's Radio Education Project." Tallahassee, FL: Florida State University, June 1991.

Imhoof, Maurice and Philip R. Christensen, eds., *Teaching English by Radio: Interactive Radio in Kenya*. Washington, D.C.: Academy for Educational Development, 1986.

Jonassen, David H., "Interactive Lesson Designs: A Taxonomy." *Educational Technology*, June, 1985.

Kaplan, Rochelle G., Takashi Yamamoto, and Herbert P. Ginsburg, "Teaching Mathematics Concepts," in Resnick, Lauren B., Leopold E. Klopfer, *Toward the Thinking Curriculum: Current Cognitive Research*. Washington, D.C.: Association for Supervision and Curriculum Development, 1989.

"Learning Centered Psychological Principles: Guidelines for School Redesign and Reform," American Psychological Association Task Force on Psychology in Education and the Midcontinent Regional Educational Laboratory, August, 1992.

Moll, Luis C., "Introduction," in Luis C. Moll, *Vygotsky and Education: Instructional Implications and Applications of*