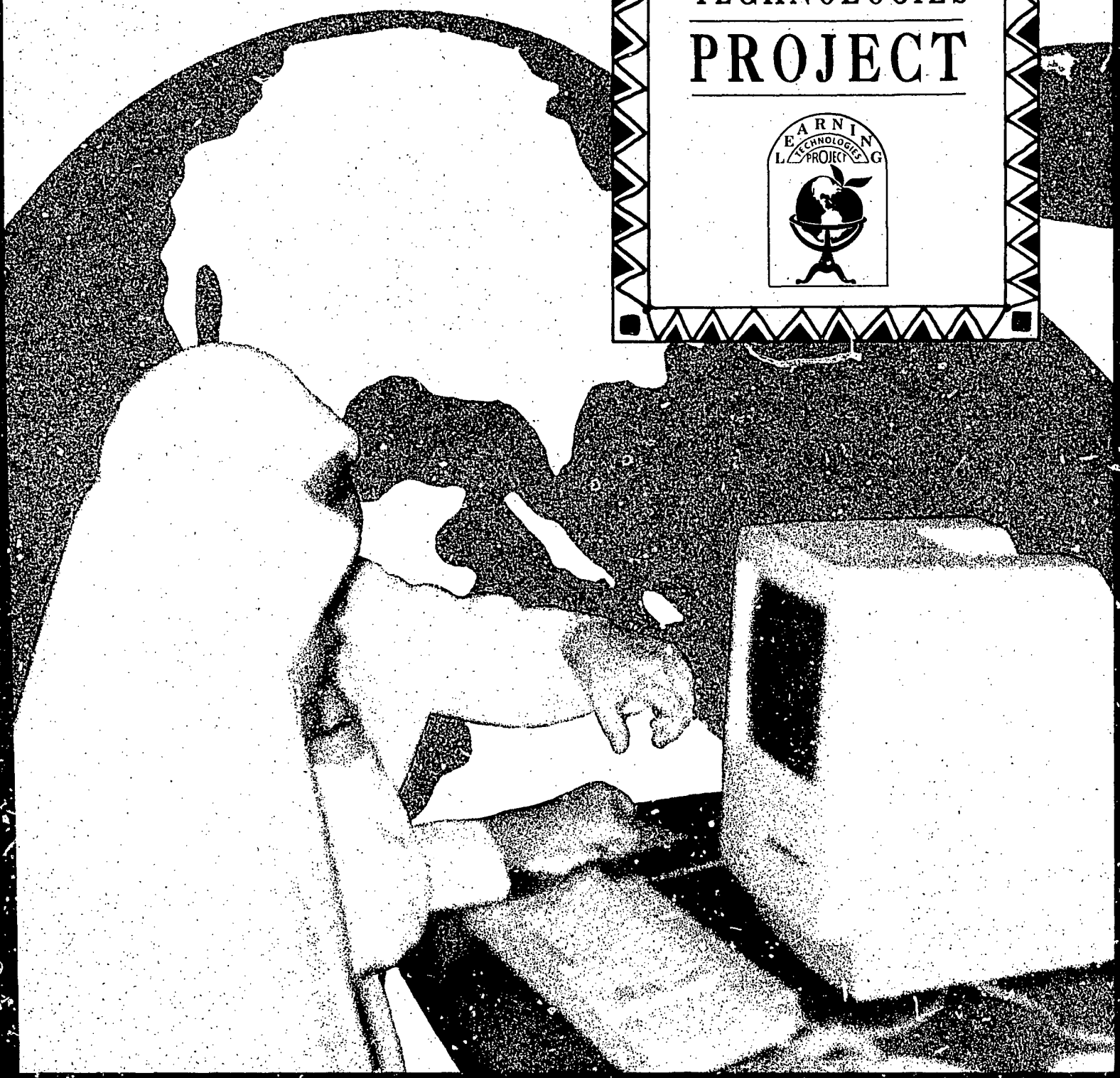
PD-ABE-046 26962

FINAL REPORT

LEARNING TECHNOLOGIES PROJECT



PD-ABE-046

THE LEARNING TECHNOLOGIES PROJECT
(1984 -1991)

FINAL REPORT

Undertaken through
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between

The Office of Education
Bureau for Research and Development
United States Agency for International Development

and

Institute for International Research
1815 North Fort Myer Drive
Arlington, Virginia 22209

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The measure of success realized by the Learning Technologies Project during the course of the past seven years was the result of contributions of many people. A special word of thanks must go to the following:

The project would not have taken place without the vision and leadership of A.I.D.'s Office of Education and a determination to stand by the effort through thick and thin. Heartfelt thanks go out to the three dedicated project officers that guided LTP, Julianne Gilmore, Cliff Block, and Jim Hoxeng, and to the three people that served as directors of the Education Office during the life of the project, Dave Sprague, Cliff Block, and Sam Rea.

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Stephen Anzalone
Director
Learning Technologies Project

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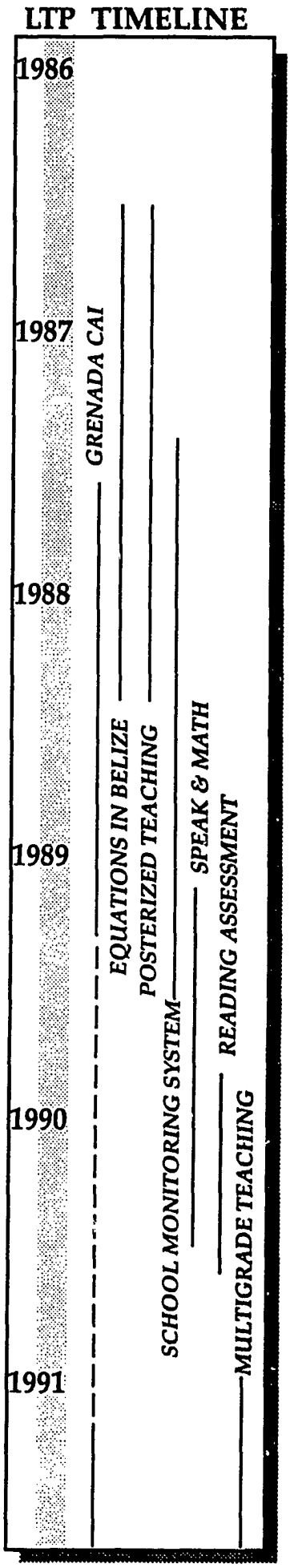
INTRODUCTION

In 1984 the Education Office of the present Research and Development Bureau of the Agency for International Development (A.I.D.) undertook the Learning Technologies Project (LTP). LTP examined a range of educational technology applications, from pencil and paper to microprocessor driven devices. Its purpose was to determine the learning gains that might be produced and the impact of the technologies on the teacher and students. Ultimately the project was to provide definitive knowledge on costs, learning gains, manageability, and acceptance of a wide array of learning technologies.

A five-year cooperative agreement under the Educational Technology Studies and Applications Project was awarded to the Institute for International Research (IIR) in September, 1984. The agreement was extended for two years, ending in January, 1992. Total project funding was $1.9 million dollars which provided about $250,000 funding per year over the seven years of the effort. (As a part of that extension, the final year of the Communications Support Project (CSP) was funded. Details of that effort are included in the final report of CSP.)

LTP was originally conceived to fund an "umbrella organization" that would subsequently support a number of small pilot applications of learning technologies. Each pilot would be funded through sub-agreements to leading institutions at a level from $100,000 to $200,000. As funding became more scarce, the notion of an umbrella to various efforts was abandoned and replaced by a strategy for smaller scale, lower cost pilots with less reliance on sub-agreements. Most of that activity was consolidated in Belize.

This document is the final report of the Learning Technologies Project. The first section, "Evolution of LTP: Some Thoughts along the Way," documents the rationale that guided the project design and the events that modified those ideas. Even the latest versions of these ideas still merit debate and scrutiny; they do not rate the prestige of being a "lesson learned." The second section, "Review of Project Activities," summarizes the outcomes of tested technologies that ranged from evaluating an integrated mini-computer learning system in Grenada to inexpensive mathematics games in Belize to hand held electronic devices that drilled arithmetic. The third section, "Linkages and Contributions," details LTP's participation in various forums and contributions to publications.



The first section is a history (the history of how thinking evolved), the second section is description (reporting discrete field activities), and the third section is, again, a history (an accounting of participation at conferences and contributions to publications). To help the reader tie these together, a time line side bar spanning the major project field activities is provided on each page.

In September, 1990, the Education Office funded LearnTech, a five year contract with the Education Development Center (EDC). IIR, as a sub-contractor to EDC, is assisting in a continuation of the exploration of the potentials of electronic learning technologies. Since September, 1990, LTP and LearnTech have coordinated activities for both projects in order to eliminate redundancies. This final report for LTP will document all efforts carried out by IIR since September, 1990 and will not attempt to force a distinction between endeavors under the aegis of LTP or under LearnTech.

SECTION 1: EVOLUTION OF LTP: THOUGHTS ALONG THE WAY

1984

In early 1984, several members of the Education Office in what was then the Science and Technology Bureau, began planning work for what was envisioned as a small scale exploration of the effects of electronic technologies in developing country classrooms. (A stylistic note: that office was known then as "S&T/ED;" this report will preserve that convention.) Like many U.S. education professionals at the time, some members of S&T/ED optimistically embraced the potential of using software in the classroom to achieve learning gains. Order-of-magnitude learning gains seemed possible from sophisticated tutoring systems being designed in the U.S. The staff members argued that learning gains from commercially available software seen in the U.S. (averaging about half an effect size) could be even greater in developing countries, where facilities and materials do not match U.S. classrooms.

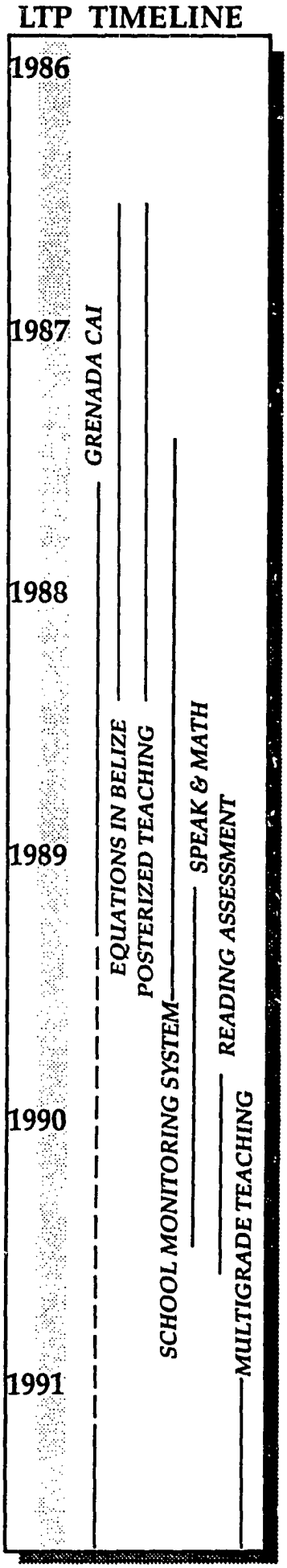
Cost was the prohibitive issue. Not simply the cost of the computers was at issue, but also the cost of software development, and cost of repair and replacement. But the trend was then (and continues to be) that hardware costs come down. So, the project proponents argued, A.I.D. should fund investigations, carried out in small scale pilot studies, to find out what magnitude of learning gains were possible from commercially available software and what logistical and management difficulties were likely. Then, knowing the likely gains and the logistical obstacles, when the costs dropped far enough, A.I.D. could draw on its field experience to advise developing nations how to exploit the opportunities for learning provided by the microchip.

Skeptics, driven by cost and management complexity issues, insisted that simpler technologies (for example, pencil and paper materials) be included in the pilot research studies.

On September 24, 1984, S&T/ED entered into a cooperative agreement with the Institute for International Research (IIR). IIR was to act as an "umbrella organization" to identify potential technologies (via seeking proposals from potential sub-grantees), to support the pilot research sites, and to provide a uniform evaluation scheme.

1985

In January, 1985, the Project hosted its first Project Advisory Committee meeting. Attendees included representatives from industry (IBM, Control Data, Texas Instruments, Apple Computer, WICAT Systems) and from educational consulting, including AED, EDC, Bank



Street College, BBN (Bolt, Beranek, and Newman), Friend Dialogues, and the University of Michigan.

Project staff laid out its plans for identifying and selecting pilot research studies and sought the Committee's input on considerations to keep in mind. In particular, LTP staff wanted to know whether technologies were coming down the road that could truly revolutionize the teaching/learning process. None was. Then-current challenges were in developing software to exploit CD-ROM/videodisc capabilities -- an evolutionary, not a revolutionary, change.

Concurrent with this meeting was an attempt to develop a conceptual framework for the results and experience of not only LTP, but for efforts to introduce technology in developing country education worldwide. A matrix detailing results and experience by school conditions and technology seemed to answer to decision makers' needs. One could learn outcomes of efforts done by similar schools; conversely, one could learn about outcomes from any technology of interest. The pilot research studies would be selected strategically to fill in missing cells in the matrix.

The request for pre-proposals for the pilot research studies called for broad applications of technologies -- excluding only radio, television, and audio tapes. (Since radio, television, and audio tapes had been tested extensively in developing countries, only marginal new experience might be gained.) The request addressed cost issues by including a "back of the envelope" formula that showed how constrained recurrent costs in developing countries really were. LTP projected that only one or two percent of a country's per student expenditure could be used to cover recurrent costs of a technology. The calculation demonstrated where per pupil expenditures are low, many students (and classrooms) would have to be served by the technology to make up the recurrent costs. Applications in technical or vocational training, where expenditures per student are usually higher, could have fewer students in the target group and perhaps more expensive technologies. LTP was trying to forfend against a-micro-at-every-desk proposals.

Three hundred requests for pre-proposals were sent out to consulting groups and educational institutions throughout the U.S. Seventy-five pre-proposals were received. Seven were selected to submit a more detailed ten-page proposal.

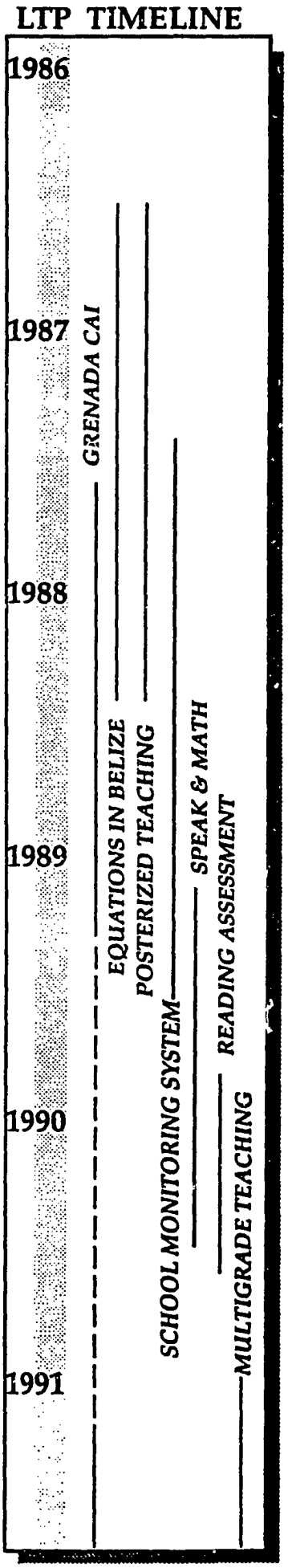
The selection of the pilot research studies caused considerable dissension among the judges. The dispute was fueled by confusion over the term "research" in the pilot research studies. Colleagues from the academic research establishment interpreted the term strictly -- using it to justify selection of proposals that parsed whether learning gains were attributable to the instructional method or the delivery technology. S&T/ED pressed for broader interpretation of research that would provide information useful for those in choosing and applying a technology. The broader interpretation of research was adopted.

Three efforts became the primary focus:

> A proposal was submitted by the University Research Corporation (URC) for "Locally Adaptable, Interactive Videodisc Instruction for Community Health Workers." Typically, medical doctors, unschooled in training techniques, conduct training for semi-skilled community health workers. Such training is expensive, and results are marginal. This proposal was particularly attractive because it would provide such basic training, freeing the doctors for other tasks. Furthermore, URC proposed using currently available instructional visuals (hence, inexpensive) and translating the voice instruction in several different languages so the videodisc could be widely distributed.
>
> Friend Dialogues submitted a proposal to develop a "smart," hand-held learning aid for arithmetic. By "smart," the aid could diagnose the source of the difficulty a student was having and would present drills to remedy that deficiency. The units would also be able to track the progress of students. High projected development costs gave rise to funding the effort in two stages -- a design stage that would do the research necessary to develop the diagnosis algorithms and a development phase in which the microchip would be produced.
>
> Community Systems Foundation (CSF) of Michigan submitted a proposal for the "Acquisition of Mathematical Skills in a Game Environment" with separate trials for teacher training college students and elementary school students. CFS's proposal was particularly attractive because it tested both a game board version and a computerized version of a mathematical game, EQUATIONS, already well researched and well received in inner city schools in the U.S. EQUATIONS is a board game, played with six wooden cubes; the faces of each cube have numbers. In the game, a player must devise ways to use the numbers showing on the cubes in conjunction with the available mathematical functions (add, subtract, multiply, and divide) to arrive at a predetermined target number.

Concluding sub-agreements was contingent on finding an implementation site. S&T/ED entered into discussions with the Mission in Ecuador for the Videodisc for Community Health Workers and the U.S.A.I.D. Representative in Belize for the EQUATIONS Game.

The disagreement over the selection criteria for the pilot research studies had, in the meantime, played out in a budgetary arena. The academic researchers appealed selection of the pilot research studies to A.I.D.'s Director of Human Resources. While the Director was



not necessarily sympathetic to the researchers' stance, the apprehension of unsustainably high costs, long a problem with the Director, again became an issue. Moreover, the intervening year since project approval had brought scant evidence of impressive learning gains in the U.S. In a year of particularly tight budget constraints, LTP, beleaguered by cost issues, weakened through the "research" dispute, and bereft of compelling evidence of learning gains, had its funding substantially reduced.

Because of the funding situation, LTP was not in a position to support the hand-held learning aids and the videodisc project. Instead, the project would forgo the umbrella notion -- supporting various efforts in different countries -- for consolidating and streamlining efforts and narrowing the geographical focus. Belize was an ideal location: it was close by and it was English speaking. More important, educators there were gracious and willing to experiment with new technologies. (Appendix A describes the educational system in Belize.)

Negotiations with Belize resulted in a Memorandum of Agreement between the A.I.D. Mission, on behalf of the project, and the Government of Belize. The agreement was to conduct a series of trials of various learning technologies in Belize, EQUATIONS being the first. The Belize Education Laboratory, established by LTP, became the coordinating institution for these efforts.

Another opportunity knocked at LTP's door that year. Control Data Corporation had recently set up a complete instructional delivery system, a 32 workstation platform for WICAT courseware in Grenada. In hopes of being able to demonstrate the courseware's potential in developing countries, CDC asked LTP to independently evaluate the student performance. LTP was delighted to have the opportunity to examine the effectiveness of a sophisticated, integrated learning system without having to bear the expense of installation and operating such a system.

1986

Using the Belize Education Laboratory as a base of operations marked a significant change of direction for LTP. The original focus on conducting a series of studies on the application of promising technologies shifted to a more systemic attempt to

explore whether and how educational technology might enter into the pursuit of national educational goals. Activities were balanced between finding a technology to meet a specific need of educators in Belize and trying out new technologies with potential applications worldwide.

The Laboratory in Belize City was headed by a Belizean, the former head of the Catholic school system of Belize. The Laboratory, at its height, employed six persons who were working on various project activities. Four of these positions were funded by the Government of Belize out of local counterpart funds provided by the AID mission. The office was equipped to supply administrative services to support project activities and liaison with the Belize education system.

Concurrent with the introduction of EQUATIONS, a national educational needs survey was carried out by the Laboratory. Not meant to be a sector assessment, the survey was a questionnaire given to principals and teachers. The instrument contained questions asking about demographics, resource allocation preferences, critical incidents, and the potential effectiveness of various strategies to improve primary education in Belize.

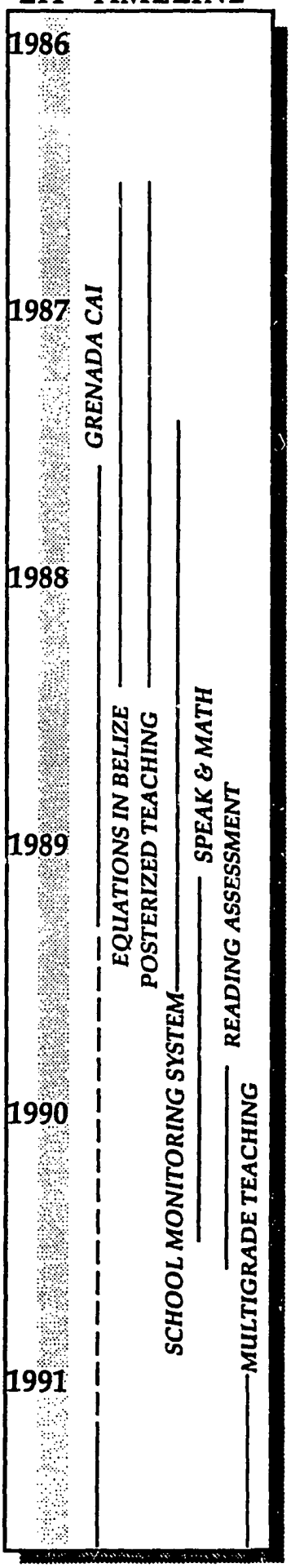
The needs assessment, or rather the process of the needs assessment, proved invaluable. Arguably, Ministry of Education officials were cognizant of the needs of schools and teachers. In this case, with the headmasters and teachers the focus of the survey, they had voice and, therefore, a stake in the actions proposed on the basis of the survey. The survey gave LTP staff entree into discussions of needs at the school level and enabled LTP staff to thrash out possible interventions directly with those who would be implementing them. LTP gained legitimacy within several levels of the educational establishment in Belize.

A primary need, recognized in the survey, was for teaching materials in the classroom. IIR had had previous experience in developing programmed teaching materials and curriculum in Liberia, Indonesia, and the Philippines. Uniting these countries' successful development of programmed teaching materials with Belize's need for teaching materials gave rise to the notion of using posters in the classroom.

These posters would be designed and illustrated using the step-by-step methodology of programmed teaching. If the integrity of the learning gains expected of programmed materials could be maintained focussing the class on a poster, then these powerful materials could be reproduced cheaply with a low per classroom (and per student) cost. Posters (one set of posters for a classroom of thirty or more students) were much cheaper than individualized learning materials for each student.

The Posterized Programmed Teaching Technology (PPTT) was born. PPTT will be summarized in Section 2. Its importance, however, is that it was a significant departure from LTP's initial attitude towards technology: it was not a demonstration in a developing country of an exogenous learning technology. PPTT was, instead, endogenous -- crafted from needs, and shaped by the previous related experience and pruned by cost constraints.

LTP TIMELINE



1987

As an outgrowth of the work underway with microcomputers in EQUATIONS, the Ministry of Education in Belize along with the U.S.A.I.D. Mission became interested in a school monitoring system that could automate information about schools and attendance. While management information systems were by no stretch of the imagination a "learning technology," LTP, using Mission funding, arranged for consultants to work with the Ministry in building a school monitoring system and training Ministry staff to operate it. Again, LTP exercised its revised mandate of finding an application of technology to address an already existing problem: in this instance, LTP assisted Belize in utilizing a well understood technology to improve the management of the educational system.

By late 1987, the project was beginning to learn of various applications of microcomputers in developing countries. Not only A.I.D. officials, but World Bank, O.A.S., and Unesco colleagues knew of practitioners who were planning or had already gotten some effort underway. True, the information was anecdotal and the classrooms were often in elite schools. Still, the forces for change had been set in motion and those who were a part of that change were optimistic of potential gains that educational software and learning with computers might bring about. Nay sayers, those who could never envision or justify the use of microprocessor driven technology in developing country classrooms, were more difficult to find. Clearly, a forum for the discussion of the use of microcomputers in the classroom had begun.

In retrospect, perhaps it was because of the activity in the pilot work thus far, or perhaps it was because the value of the knowledge LTP was discovering, S&T/ED seemed to see benefit in keeping its place at the worldwide discussion table by contributing the experiences of LTP. To project staff, the legitimacy of LTP seemed validated.

1988

The first project results were reported in 1988. EQUATIONS reported findings that were at best confusing and at worst disheartening and none were statistically significant. Students who had spent considerable time playing the game EQUATIONS

in classrooms did not show gains similar to those shown in inner city schools in the U.S.; if fact, they were not even as strong as control students! Students who played the game on computers did perform better than control students, but the effect was small, not statistically significant, and risky to attribute to either playing the game or using the computer.

LTP staff wondered about the likely effectiveness of instructional methodologies (games, in this instance) that are used as a substitute for direct instruction. Simply put, direct instruction (typical of the approaches of Radio Math, Radio Language Arts, and Radio Science) works. Games, like EQUATIONS, that call for an inductive, exploratory mode of learning, may not be that effective in developing country classrooms. Perhaps interventions like EQUATIONS require too great a leap from the traditional to the exploratory; children in developing countries may not know what is expected from them and how to learn in these ambiguous situations.

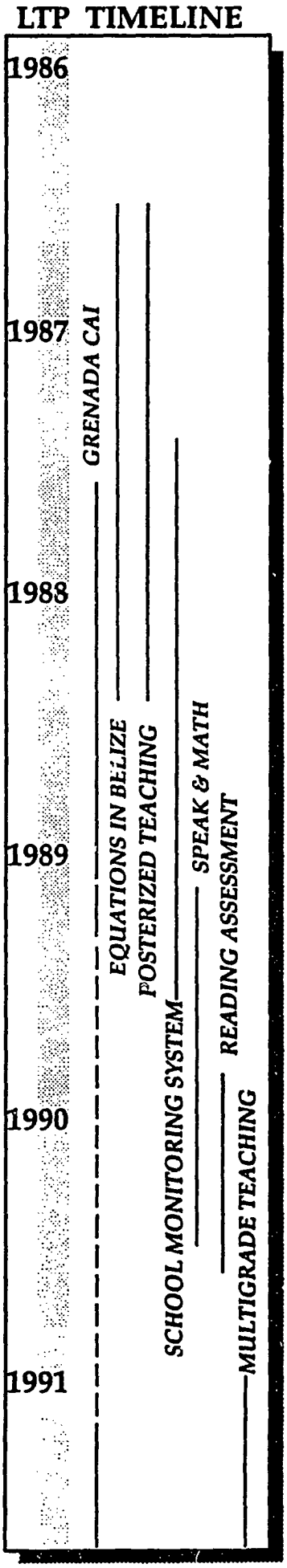
Later that year, S & T ED's Basic Research and Implementation in Developing Education Systems Project (BRIDGES) tapped LTP staff to contribute a state-of-the-art paper on the use of educational technologies applications in developing countries.

The reaction to the BRIDGES publication was important for LTP's sense of direction. For one, the publication proved to be one of BRIDGES "best sellers." This indicated an interest in educational technology in developing countries that surprised many people. Second, the good reaction to the publication by colleagues in the academic community and donor agencies suggested that the usefulness of syntheses of research. It also indicated the value of looking at a wider range of educational technology than was considered at the outset of LTP.

The thinking required in doing the paper, tempered by the EQUATIONS results in Belize, led LTP staff to an insight helpful in delineating theoretical and practical issues involved in applying learning technologies. Current thinking in the U.S. differentiated the use of educational media and instructional methods. The instructional method was largely responsible for the learning effect, regardless of the delivery system. The delivery systems, whether textbooks or radio or computers, were generally interchangeable. Content determined the selection of the instructional method, and choice of the media was secondary.

While such was current theoretical thinking, practical applications in developing countries were always driven first by cost constraints and secondly by the manageability of the delivery system. Contemplating instructional methods to the exclusion of early consideration of the delivery system (its cost and manageability) was simply shortsighted. A more apt metaphor was thinking of a marriage of instructional method and delivery system. Interventions that work, like interactive radio, combine a powerful methodology and an affordable technology. The trick is to unite them in one package.

The notion of thinking in terms of a marriage of instructional method with delivery system was first presented at a two week seminar on "Using Technology for Education and Training," sponsored by the Economic Development Institute of the World Bank. The event signalled a new interest in the Bank in instructional technology, although the Bank's focus was on



educational technology for distance education applications more than for classroom applications.

It may be sensible to blur the distinction between distance education and classroom applications however. Full use of computers involves telecommunications links, and any device with inherent telecommunications is ideal for distance education. A computer with a modem and a network becomes a versatile tool. It can deliver software to teach or train using almost any instructional method and it can channel both instruction and student response to any other link. Software and communication links are powerful tools for either application.

As the year drew to a close, a second advisory panel was convened to review LTP's progress thus far. LTP staff presented the evolution of the rationale and approaches for LTP. The consensus of the group was that it was not too early to move ahead with the plans for systematic testing of various technologies. Again, LTP staff canvassed these leaders of industry, education, and development assistance on whether electronic technologies epitomizing the marriage of instructional method with delivery system were being overlooked. Although none was apparent, the advisory panel urged LTP staff to look for niches where a technology coupled with an instructional methodology might make a big difference.

1989

In 1989, results from PPTT came in. For the most part, the results were encouraging. Costs of the posters were kept to an absolute minimum, and teachers appreciated the support such structured classroom aids provided.

Using posters for teaching social studies showed gains of a standard deviation -- an impressive gain for any educational intervention. Even though no differences in performance gains in reading were shown, no deficiencies among the poster trained group were manifest either. The posters were designed to drill decoding skills necessary for reading; perhaps decoding skills practice was not sufficient to attain comprehension in fluent reading. Alternatively, the single year of posters instruction may not have been sufficient to accelerate reading skill acquisition beyond traditional standards.

The heartening results of PPTT showed the earmarks of a successful marriage between an affordable, manageable delivery system with proven instructional methods.

Due to funding shortages, the posters trial could not be extended to subsequent years. The results were favorable enough to suggest that other application possibilities might be pursued under LearnTech. Adding sets of posters to support interactive radio lessons could be a promising combination.

Data from the three year trial of the computer assisted instruction at Grenada were completed in 1989, too. The trends were clear: the students using the computers got progressively better. The trend was clear in mathematics, resulting in CAI students outperforming students in advantaged, urban schools. In reading, a "startup cost" was overcome handily by the third year. The effects of systematic presentation of materials in reading and mathematics seemed to be cumulative. (Greater detail of the work in Grenada is provided in Section 2.)

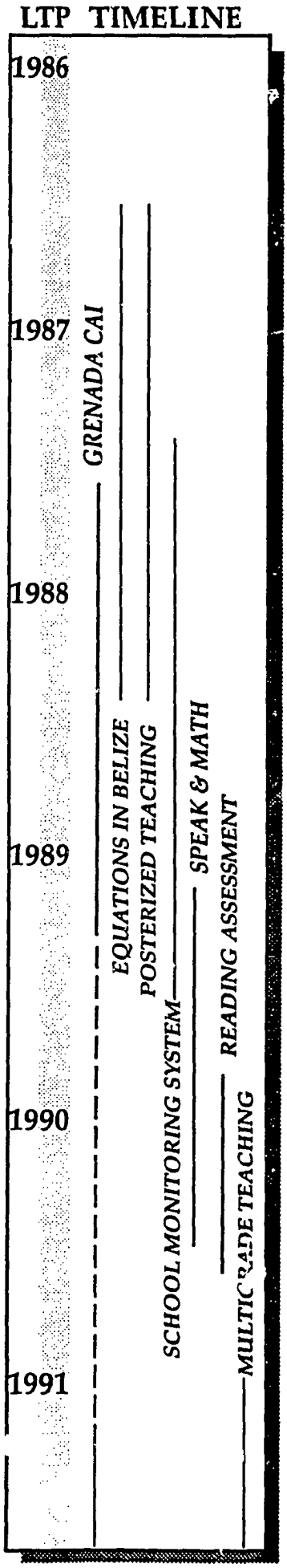
Many doubts on the limited usefulness of sizable investments in hardware and courseware for integrated learning systems, like WICAT, have been allayed. New systems have open-architecture which allows all DOS-based software programs to be run on the workstations. Now teachers can use a wide variety of software, not just the WICAT software. Moreover, business related instructional uses, such as teaching accounting or data management software applications, become possible.

The advantages of having one unified courseware system became evident: not only could a systematic and uniform curriculum package be leveraged to its full potential, but training of teachers could be kept to a minimum. The lab technician has only to learn one software program and teachers can turn over the instructional time to that technician.

The experience at Grenada, as well as a study of the costs of educational computing in Belize, suggested one approach to managing costs. The first focus should be to maximize learning gains. Next step is to look for ways to increase the audience, the number of students who can benefit; this lowers the unit cost. Costs can be lowered still further by cost recovery, such as charging fees to clientele who can afford to pay.

As a result of the BRIDGES paper that surveyed the outcomes of various electronic instructional technologies for primary school, the World Bank approached LTP staff to write a subsequent paper examining implementation issues with respect to using educational technology at various levels of general education. When LTP began, possible difficulties in wide-scale implementation were not an issue simply because few were convinced that computers in developing country classrooms would be manageable or effective. By now, more was known and time had come to look ahead.

This document became an instrument to articulate more carefully a definition of educational technology as a concept and a strategy. The exercise provided the opportunity to show that the obstacles facing the introduction of new technologies were similar to those facing more



conventional interventions. The paper concluded that much more needs to be learned about the use of computers in developing countries before recommending investments in this technology. Some in the Bank now seem to share the "Let's learn more" view point, rather than dismissing the use of educational technologies as premature.

As the year closed, one last synthesis of experience was produced. Very early in the project, LTP staff and S&T/ED representatives alike wanted to develop a matrix that would capture the experience of using learning technologies under various conditions and for distinct purposes. Even as LTP studies were underway, it became increasingly clear that experience was so sparse that a matrix would comprise mainly empty cells. Documenting gaps in knowledge is not informative to policy makers or decision makers. In order to put what we did know in more usable form, LTP used a software technology, hypertext, to document experience with a range of educational technologies. LTP had created its own software application, the Learning Technologies Digest.

Hypertext allows a user to get more detail about text displayed on a computer screen. In the Learning Technology Digest, the user first gets a general summary of the research about a class of technologies, for example, interactive radio. From that screen, the user can get an abstract of any project that was mentioned in the research summary.

Hypertext is not like using a data base that uses query language and results in a list of projects, which may be documented in text elsewhere. In hypertext, descriptive text is on the screen, and the user gets there by "pointing" to topics of interest, not by programming a query. Using hypertext, a person does not have to have to know all the questions in advance; the user can "browse" -- pointing and going to topics of that may seem interesting but without knowing explicitly what information is sought. Such an application of a hypertext could be ideal for a policy maker wanting to tap previous experience without wanting to learn the intricacies of data base programming.

The Learning Technologies Digest pulled together experience from a wide range of educational technologies, including radio. Both completed projects and on-going work drawn from the world over were included. The digest is surprisingly large; four standard floppy diskettes make up the reference work. Educators, worldwide, have praised its usefulness, not only the

user-friendliness of the hypertext format, but also having a compendium of the experience on educational technology assembled and linked to summaries of the research about it. LearnTech will provide for an update of the Digest during 1992.

Much of 1989 was involved in preparing for the Education for All conference in Jomtien, Thailand. Since the conference was mobilizing support for education for "all," LTP wrestled with the question of what role educational technology might play in this effort. Perhaps educational technology would be seen as a distraction to efforts to make basic education available to more children.

1990

At the Jomtien Conference in early 1990, those concerns were allayed. Concerns for "quality" in education were prominent. Donor agencies, particularly Unesco and UNICEF, maintained that media and technology were, indeed, a part of that effort. The proof of that commitment followed shortly: the conference video had scenes featuring students at computers. The world had changed.

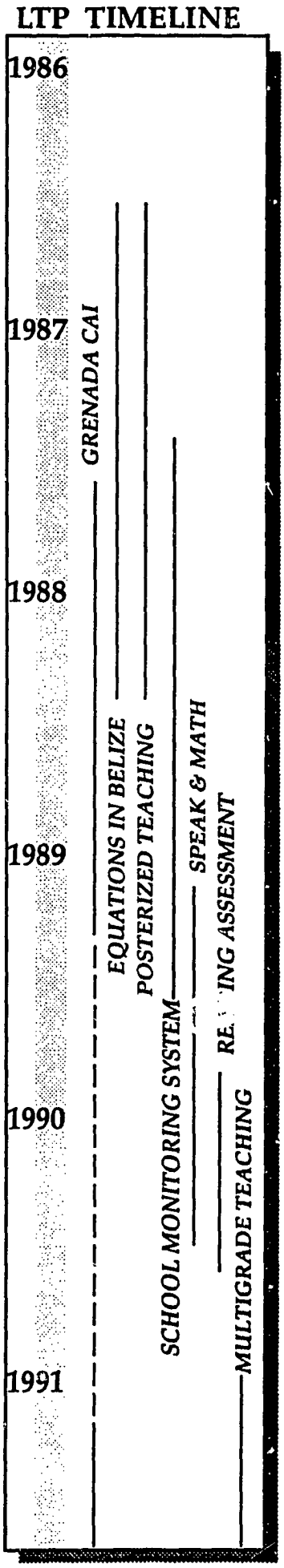
In Belize, work was finishing up on the Speak and Math trial in rural schools. What had been clear from early in the project any microprocessor driven device, appropriate for elementary level students, would look much like the Texas Instruments Speak and Math and Speak and Read units -- self-contained, battery operated, more or less indestructible. S&T/ED had, over five years earlier, sponsored a test of these devices in Lesotho. That trial was only twelve weeks, however, and many questions remained unanswered.

The encouraging results are described in Section 2, Interestingly, of all the reactions and acceptance of the interventions tried by LTP in Belize, the Speak and Math was the most enthusiastically received. LTP had found another prototype for the "marriage" of instructional methodology (here, simple drill and practice) with delivery system. This marriage seemed to be extremely happy.

The Speak and Math trial helped provide further insights into thinking about costs. Looking closely at the costs, LTP staff found that recurrent costs for Speak and Math (primarily the batteries for operation) could be lowered by a third if solar rechargeable batteries were used.

Also concluded in Belize was the reading assessment work done by the University of Massachusetts. The particular outcomes of that endeavor are recounted later. The completion of the reading assessment in the same year as the Speak and Math trial provided an interesting juxtaposition in the potential uses of microprocessor driven technology. One application was for the classroom; the other was for assessment.

Clearly, LTP had broadened its perspective. Early in the project, classroom interventions were the focus. Only later did LTP come to value uses, such as assessment or curriculum development, that may contribute indirectly to improve student instruction. Additionally,



others have observed that not until Ministry employees themselves become conversant with computers will the idea of classroom application begin to take hold.

1991 began the transition to a joint programming of activities between LTP and LearnTech. LearnTech opened up opportunities to experiment with combinations of technologies because the project design neatly put all the educational technologies into one basket. The technology of greatest interest was interactive radio, and rightly so. But all technologies could play a role, either as support or in their own right.

The greatest flexibility in LearnTech comes in reexamining old technologies for new applications. Take, for example, television. Years ago, after a few expensive trials, many dismissed television as an educational intervention because programs were costly to produce and teachers found rigid broadcast schedules too restrictive. In the last few years, televisions and VCRs have invaded every corner of the world, even where no grid electricity is available. Thanks to VCRs, television is free from any broadcast constraints.

LTP/LearnTech staff saw possibilities of expanding, too, the idea of a localized, pilot site to working in regions, with indigenous institutions serving that region. The term, "gateway institution," describes institutions such as INNOTECH, the Regional Center for Educational Innovation and Technology based in the Philippines. During the following year, discussions for collaboration between LearnTech and INNOTECH were carried on.

1991

S&T/ED asked LTP to look again at students in Grenada. A natural experiment had been going on: not having a source of uninterrupted power had shut the lab down for two years, so students there had not had the support of the computer assisted instruction (CAI). LTP re-administered the tests developed by the project earlier, to assess the achievement of the students. Additionally, LTP looked at the results of the Common Entrance Exam taken by all students in Grenada. Learning gains as measured by both tests were down significantly from where they had been. LTP had strong evidence not only that CAI had made a

difference, but that not having CAI made a difference, as well, except in the wrong direction.

Work at the Belize Education Laboratory continued. The principal activity was launching an effort (that will be continued under LearnTech) to improve the "technology" of multigrade teaching. Multigrade classrooms are common in rural areas throughout the developing world, and Belize was no exception. Multigrade classrooms pose special challenges for teachers to organize the classroom and keep the students focussed on appropriate tasks.

LTP welcomed the request from the Ministry to help find ways to increase learning gains in multigrade classrooms there. In addressing that situation the Ministry may be willing to look at possible options using educational technology that could help the teacher organize materials presentation and classroom management and help the students concentrate on the lessons.

This scenario makes an interesting counterpoint to the solution-looking-for-a-problem approach that typifies some advocates of educational technology. The Ministry, knowing well its needs, collaborates with instructional technologists to select from a number of possibilities. The resulting implementation may be the same, but the technologies and their advocates alike might be viewed differently if the first focus was on the aggravating condition. In fact, looking first at the problems of multigrade teaching and determining what classroom technologies might be appropriate has inspired a similar investigation in Indonesia under IEES.

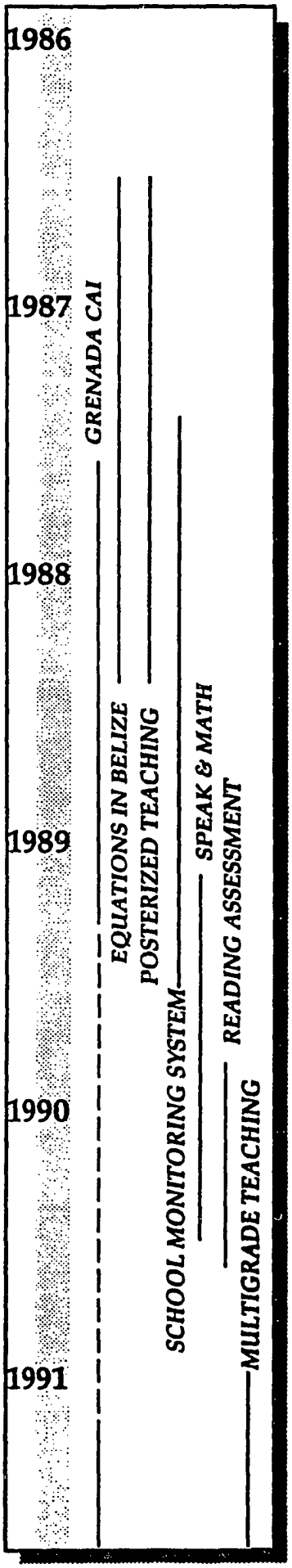
Ironically, perhaps the most durable and suitable innovation that LTP produced during its tenure was unintentionally developed: the Belize Education Laboratory. On one hand, the Lab became a channel for a fruitful dialogue with educators in Belize. On the other hand, educators in Belize had a locus of technical support, providing resources and expertise. From a practical, logistical standpoint, the Lab enabled LTP to send consultants to Belize who could hit the ground running, get set up quickly, and produce results soon.

The greatest testimony to the Belize Education Laboratory's success is simply that after over five years and a change of projects, it is still going strong and the collegiality among LTP, the Belize Lab, and Belize educators continues.

In the fall of 1991, LTP assisted the U.S. Coalition for Education for All in preparing its conference "Learning for All: Bridging Domestic and International Educators." Further evidence emerged of the growing recognition of the possibilities educational technology offers developing countries. In closing remarks to the conference, Wadi Haddad, now the World Bank's ambassador to the United Nations, suggested that one of the areas the U.S. has something special to offer others is in educational technology.

By the end of 1991, little doubt remained whether microcomputers would become a part of educational efforts in developing countries. Micros were in classrooms, micros were in curriculum development units, micros were in evaluation and testing units. Some countries like Costa Rica and Malaysia have already made significant progress on introducing computers in their education systems.

LTP TIMELINE



LearnTech has been asked to assist Costa Rica in undertaking a study of their national scale implementation. LearnTech has received a request from U.S.A.I.D. in Honduras to advise the Ministry of education on plans to introduce computers in secondary schools. The Inter-American Development Bank reports discussions with other countries in the Latin American Region wanting to install microcomputers in school systems.

Secondary schools seem the most likely place to concentrate investments in classrooms. During 1984, as LTP was being designed, S&T/ED advocates suspected such, but they were constrained by A.I.D.'s mandate to focus on basic education. Happily, since then, many countries have expanded their cycle of basic education to include junior secondary as well. Thailand has gone a step further with compulsory attendance through the ninth grade.

Generally, in elementary grades per student expenditure is low; it rises with each consecutive level of schooling. Adding microcomputers to an elementary classroom increases the per student expenditure much more dramatically than in secondary classrooms. So, even though the microcomputer and software cost the same, it becomes relatively more affordable in higher grades.

The cost issue that dogged LTP from the beginning remains unresolved. The costs of the technology are still high, but the perspective is different. Microcomputers will gradually become part of the scene in schools and classrooms where they can be afforded by one means or another. Showing high learning gains from some software is less imperative as teachers and decision makers begin to see microcomputers as simply another means to achieve educational ends. Microcomputers and software are not so much tools for teaching, but tools for learning how to organize and communicate knowledge across many disciplines. Many countries share the value placed on computer literacy that President Bush mentioned in his 1992 State of the Union address. The costs decision makers seem to be focussing on now are not the costs of hardware, rather the costs of being left behind.

COMPUTER ASSISTED INSTRUCTION IN GRENADA

In the mid-1980's, Control Data Corporation, through its subsidiary Control Data Caribbean Basin, Inc., began marketing in the Caribbean by providing consulting, education, training, and computer services. As a part of a joint venture with WICAT, CDC wanted to demonstrate computer assisted instruction capabilities, both in direct instruction and in remedial instruction for dropouts. To do this, CDC awarded the Ministry of Education in Grenada a grant to operate a 32 station mini-computer learning laboratory in Crochu, a small town located seven miles outside of the capital. CDC provided the workstations and the complete K-8 WICAT courseware selection for reading and mathematics, developed for U.S. schools.

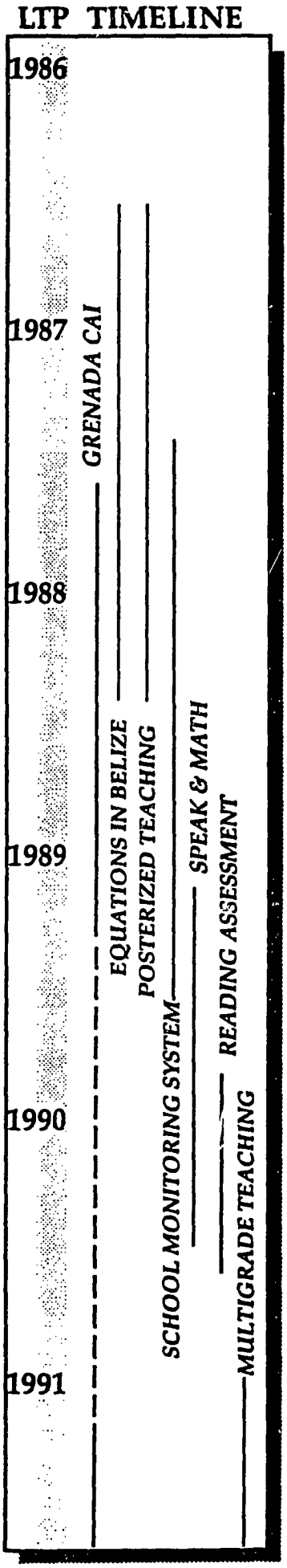
The Grenada educational system, like many in developing countries, suffers from poorly trained teachers, lack of a well-planned curriculum, and scarcity of instructional materials as essential as pencils, paper, and textbooks. CDC wanted to know whether computer assisted instruction (CAI), developed for use in the U.S., could be used to overcome these deficiencies in Grenada.

Arguments against expecting a positive impact were linguistic and cultural. English is the national language of Grenada, but differences in vocabulary, pronunciation, and grammar with U.S. English are substantial. Moreover, visuals of deserts and skyscrapers may have little meaning to young Caribbean children whose early experience has been with lush, green mountains meeting expansive waters. These cultural and linguistic differences, and the confusion they might create in students, could negate potential benefits of CAI.

CDC sought the participation of the LTP in conducting an evaluation of student performance at the lab over a three year period. LTP staff saw the Control Data invitation as an opportunity to conduct a systematic study of a long-term application of microcomputers in the classroom. The equipment and courseware were expensive, even for U.S. classrooms, but, because of the grant, cost was not a pressing issue. Evaluating the students, over time, with recognized courseware, provided a best-case scenario to set benchmarks for learning achievement that could be possible.

LTP, working with colleagues from the University of Massachusetts, evaluated the reading and math achievement of the students in standards 1 through 5 who substituted CAI instruction for part of their conventional instruction. These students were compared to students from control schools (in similar economic and social communities and school settings) and to a school in an urban area, reputed to be one of the better schools on the island.

Power supply problems hampered the first year's implementation. Unexpected, however, were keyboard problems -- local ants found the glue holding the keys in place a delicious addition to their cuisine. Still, the students during the first year received between 30 and 35



hours of CAI. During the second year, students received up to 50 hours of instruction and up to 60 during the third. After the third year, power supply problems were causing unacceptable damage to the equipment and the lab shut down for eighteen months until an uninterrupted power supply was installed. Beginning with Fall, 1991, the lab is again up and running.

Because no suitable measures of math and reading achievement based on the Grenada curriculum existed, colleagues from the University of Massachusetts and teachers selected by the Ministry of Education devised the Grenada Achievement Test. Students in Crochu and in the control schools were tested three times, in September, 1987, in May, 1988, and in May, 1989.

A reading comprehension testing innovation, the sentence verification technique, was incorporated in the Grenada Achievement Test. The technique, that uses texts from grade-level curriculum, has been shown to produce reliable and valid tests. The test development does not require specialized competence, allowing local school personnel to develop their own tests and establish norms with only minimal training. In Grenada, the reliability of the test was measured close to 0.8.

CAI had a generally negative impact on reading performance during the first two years of the effort. In the third year, reading CAI showed a beneficial effect for all standards. Math, on the other hand, showed gains that were almost uniformly positive throughout all years of the effort. The evaluators offered an explanation that CAI for language instruction in dissimilar language situations has start-up costs for students who must adapt to new language usages before making learning gains. Noteworthy is the observation that once the students paid these start-up costs (during the first two years), their performance in the third year surpassed the control classes who had continued with the standard curriculum.

CAI instruction benefitted lower ability students more than higher ability ones. Interestingly, these results ran counter to the perceptions of teachers at Crochu school who thought the brighter students were benefiting more. Finally, no differences between the achievement of boys and girls were significant.

Lessons learned from this implementation of U.S. courseware in a developing country setting include ways in which teachers could smooth out the cultural and linguistic "bumps" in the CAI lessons, such as previewing the lessons then writing materials so that a

child could understand the materials appearing in the lesson. These materials could be compiled into booklets.

A technologically elegant, yet costly, enhancement would be substituting the local dialect for the oral material in the lessons. Less daunting technologically would be including several reinforcement schemes (the happy face that appears when the answer is correct) so that the most culturally meaningful one could be selected. (Crochu students did not comprehend the uses of smiling and frowning faces or the fireworks display as reinforcers for correct or incorrect answers.)

A lesson so frequently cited in studies of effectiveness of CAI in U.S. classrooms was cited again by project evaluators: school personnel need familiarization training. In particular, teachers need to understand the curriculum orientation of the CAI so that their efforts are not at cross-purposes. Also dispelling myths -- such as "Better students will get more out of CAI" -- will help teachers use the system to its greatest effectiveness.

Disk crashes due to power fluctuations became too frequent. LTP seized the opportunity to learn the extent to which gains were attributable to work in the lab. If work with the WICAT courseware was having an effect, then achievement scores for students at the Crochu lab should begin to drop. LTP tested the students at the end of both years, and the scores did, indeed, drop.

An uninterrupted power supply is now installed at Crochu and work at the lab is working again. LearnTech will continue the testing work begun by LTP, beginning with the completion of the 1992 school year.

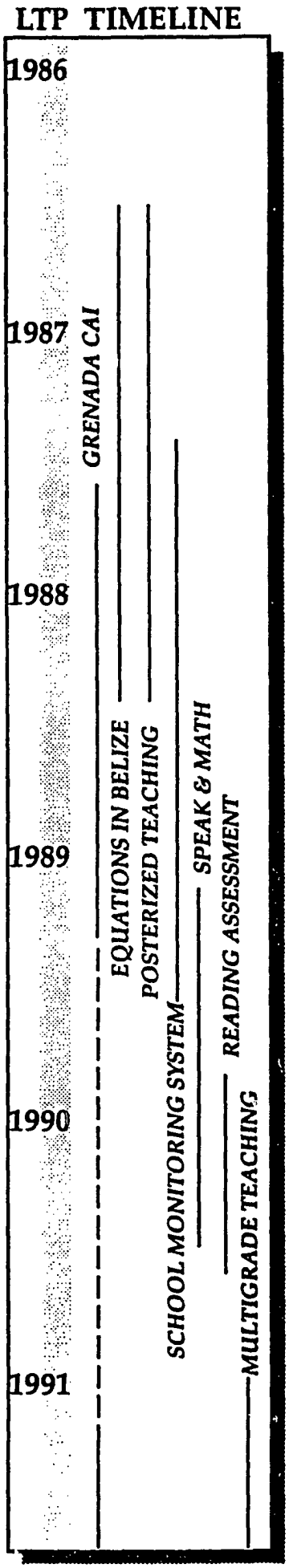
All in all, both the experience and the outcomes at Crochu were positive.

THE EQUATIONS GAME

The first learning technology chosen and implemented was the EQUATIONS Game that taught arithmetic and algebraic concepts and skills. In September, 1986, the Community Systems Foundation began teaching the use of the EQUATIONS board game to classes at the Belize Teachers' College classes and later in primary schools (to Standards 4, 5, and 6). (A description of the Belize education system is in Appendix A.)

EQUATIONS is a board game, played with six wooden cubes, with a number on each face. The point of the game is to combine whichever numbers appear using the available mathematical functions (addition, subtraction, multiplication, and division) to arrive at a target number.

A class of students is divided into three teams. These teams are selected to have strong players and weak players. In a match, the strongest players from all three teams play against each other, and so that players representing each team are of approximately equal ability.



In a match itself, points are won or lost on the correctness of the constructions yielding the target number. One player can challenge another player's construction. If the challenge is sustained, points are awarded to the challenger's team. If the construction proves true, the challenger loses points. Points for winning a match count towards the team total.

In studies done in the U.S., EQUATIONS showed striking learning gains among inner city classrooms -- improvement was twice that of control classes! Moreover, the game could produce learning gains even if the teacher was not exceptionally strong in math.

The success of EQUATIONS has been explained by two factors: its use of ability grouping and its emphasis on active participation.

EQUATIONS came in a software version as well. A student plays against the computer in a match. The software is programmed to challenge incorrect constructions. The computerized version is particularly useful for advanced students to strengthen their knowledge of mathematics.

EQUATIONS was chosen as the first demonstration of a learning technology because it had been proven in a classroom, the manual version would cost about $2 per game set ($20 per school), and testing the computerized version of EQUATIONS provided the opportunity for a comparison of the high-tech versus the low-tech version. (LTP suspected that the high-tech version would bring about larger gains.)

The outcomes were as surprising as they were disappointing. In both the Teachers College and in the classrooms, the pencil and paper (manual) version of EQUATIONS showed no learning gains over control classes. More than one measure of mathematics achievement was given; still the results were consistently non-significant across these measures. There were even some instances where EQUATIONS classrooms' scores were "in the wrong direction." Classes that used computers did show some learning gains and a better attitude towards mathematics. But, very few of the computer classrooms' performance improvement reached significance.

These equivocal results prompted a re-examination of methods and assumptions. Project staff ruled out inadequate

implementation: the team from CSF was conscientious and the local consultants were competent and industrious.

Perhaps the newness of the game, the time required for learning, and the cultural obstacles to changing the focus in the classroom from the teacher to the game constituted a challenge not easily overcome in a year. Cultural expectations may limit the success of methodologies in the classroom; an effective innovative approach in one setting may fall flat in another.

Finally, games and other innovative technologies may provide excellent practice at the margins, but they are no substitute for direct instruction. In other words, direct teaching methods might be the most efficient use of classroom time until students reach a certain proficiency. Technologies, such as interactive radio or Speak and Math, that use direct instruction methods seem to have an impressive and immediate effect. Once that proficiency has been achieved, other methodologies may provide excellent tools to provide additional competence. So, the choice to use games may depend on the skills of the students.

POSTERIZED PROGRAMMED TEACHING TECHNOLOGY

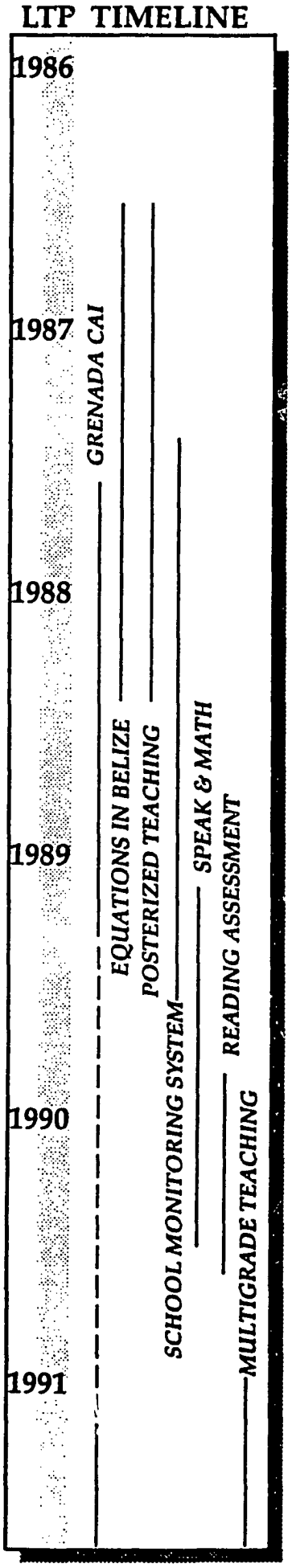
In early 1986, LTP assisted the Ministry of Education in Belize with a nation-wide needs assessment. Teachers and administrators throughout Belize called for better classroom materials, teaching aids, and teachers guides as what they needed most to improve the quality of instruction.

LTP staff introduced the notion of using a series of posters in the classroom. The posters would be designed to be more than visual aids, they would be the vehicle of instruction that carried the lesson's content. Teacher guides would accompany each set of posters making clear both the content of the lesson and how to go about teaching it.

The technology was termed "posterized programmed teaching," because it was an outgrowth of programmed teaching that had been well researched by instructional designers beginning in the 1960's. Programmed teaching guides students using small, sequenced learning steps that students practice until mastery. Posters, rather than stand-alone workbooks or software programs, were designed so that teachers could use them to focus the entire class's attention and shepherd the students in the small learning steps.

Using posters to teach, not only added materials to the classroom, but also required new teaching methods as well. Unlike other programmed learning material that calls attention to itself in a structured way, posters require a teacher to direct the students' attention and to provide the learning structure. The teacher does this by having the students make frequent oral responses to questions. The teacher signals how and when the students should respond by using hand signals, almost like a conductor guides an orchestra. Since posters, unlike other technologies, rely more on teachers, extensive teachers' guides accompanied the posters.

What makes programmed posters such an interesting technology is that the cost is potentially very low -- the posters, once produced, could be reused up to five years and student



workbooks could be produced cheaply. If posters and workbooks could replace textbooks and still sustain achievement levels, per student cost could actually be lowered. (In Belize, textbooks run between $40 and $80 per pupil per year; posters and workbooks could run as low as $15 per pupil per year.)

The Belize Posterized Programmed Teaching Technology Project (PPTT) began with a team of Belizean subject matter experts and master teachers with instructional design consultants creating 180 posters teaching the Standard 1 (grade 3) curriculum in social studies and reading. Each poster (17" by 22") addressed a single curriculum objective with a visual aid; a small box in the lower left corner gave instructions to the teacher. Materials that accompanied the posters included workbooks for students, manuals for teachers, and specially developed student achievement tests.

PPTT was carried out in 18 rural primary schools during the 1987-1988 school year. Primary school teachers participated in a two day inservice workshop in which they learned the teaching methods to use the posters. A key ingredient of this method is the teacher's hand signals so that the students respond in unison or to look at a poster or to become silent. A second ingredient is setting the instructional pace so that attention is maintained. A follow-up workshop was given before the second term began.

Reading instruction lasted 30 minutes every day; social studies instruction was 30 minutes twice a week. The first 14 minutes of the lesson, the teacher conducted the class using the posters. Two minutes were allotted for the class to shift to group or individual activities. Then, the final 14 minutes of class the students worked individually or in small groups to complete a review exercise in the workbook. During this time, the teacher provided assistance to groups or individual students.

Over the course of the year, teachers came to value the posters. They liked the well-planned, well-structured lessons. The structure and support seemed the most beneficial for inexperienced teachers. The hand signals, however, were only used occasionally, and many teachers found them awkward.

The 120 reading posters and the 60 social studies posters prepared from the curriculum were, in retrospect, particularly ambitious considering that, overall, an average of 70% of the lessons were completed by the end of the school year. Some teachers did not begin the materials on the scheduled start date, some teachers

deviated from the lessons, and some teachers were absent thus causing delays.

Significant differences for learning outcomes for social studies students were found. Even in classrooms in which the teacher had no training in how to use the posters, the posters seemed to produce learning gains. In the Belize curriculum, there are, however, no classroom materials for teaching social studies -- no books, no workbooks. So, for the social studies, the cost of developing the posters did not substitute for costs of other materials. Here, posters were an additional cost, although they did produce significant learning gains as a result.

No significant differences were found in reading scores. The picture is clouded by puzzling findings: reading achievement was inversely related to the number of poster lesson units covered. Perhaps the design was contaminated in Catholic schools where students had access to Standard I English readers required by these schools. Or perhaps the rate of presentation of materials was paced too quickly. Or perhaps the trouble teachers had with the hand signals had a more deleterious effect on reading than on social studies.

A proposed second year trial of the posters was shelved due to lack of funding. The posters remain in the schools and are being used by teachers on their own accord. PPTT was documented in a five volume set, specifying the design methodology and relating the poster lessons vis a vis curriculum objectives. The teachers' instructions and hints for each lesson are detailed in guides for each lesson.

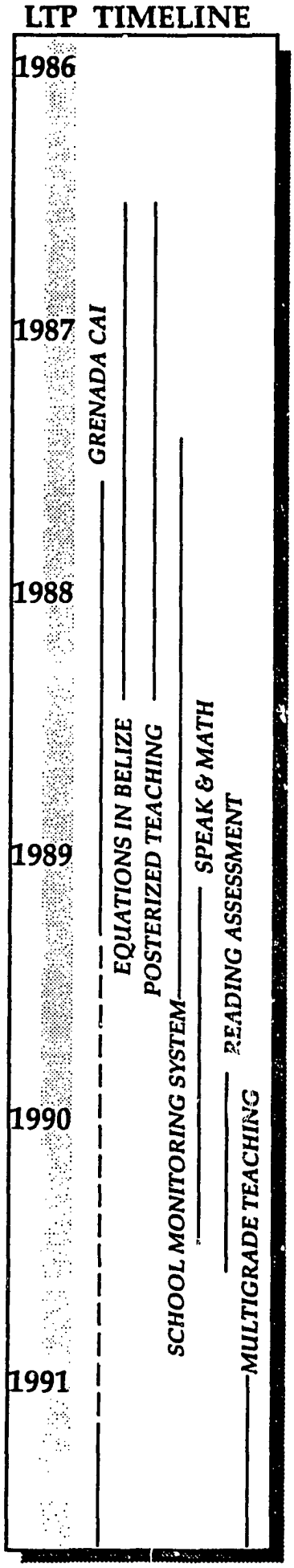
The posterized programmed teaching technology is now being adapted for use in testing situations in Swaziland.

BELIZE SCHOOL MONITORING SYSTEM

The School Monitoring System in Belize was an unanticipated outgrowth arising from the EQUATIONS project. Ministry of Education officials began to see other applications possible with computers that could help them with managing their educational system and planning for its future.

Belizean Ministry officials wanted a management information system to monitor school characteristics and performance. This information would be useful for identifying national, regional, and local needs, allocating resources, and detecting problems at early stages. Ministry officials wanted accurate student enrollment figures or precise descriptions of the physical condition of the schools. The SMS was designed to remedy this need.

What was unique to developing the SMS for Belize was the low cost. d-Base III+ was the engine for the data base, thus customized software programming was avoided. A school accreditation system had been developed for the State of Michigan, so many of the requirements of the system were known in advance. What remained was developing the questionnaire, creating data entry screens, and training Ministry personnel how to query the system.



Consultants worked with the Ministry central offices and the Curriculum Development unit to set up two computers complete with business application software. Seven Ministry staff were trained how to operate these programs, and LTP added a technical support assistant to the staff at the Belize Education Lab.

The draft questionnaire was formulated by Ministry and project staff. School principals attending SMS introductory workshops proposed substantial additions to the form. The final questionnaire had sections covering administration, enrollment, teachers, instructional materials, libraries, furniture, plant facilities, extracurricular activities, and curriculum.

In total, the twenty-two page form contained about 100 questions. The tendency had been for the form to grow, get more detailed with each revision. Project consultants advised against this but in the end acquiesced because it was easier to delete unneeded data than to go back for additional data.

Not included in the questionnaire was information on costs and expenditures at the school level and on results of the Belize National Selection Exam that every standard six student must take. Ministry officials at that time were seeking other technical assistance to assess costs and expenditures in the educational system and argued that including such data would confound that effort. The scores from the National Selection Exam were recorded and analyzed separately, and the Ministry did not support an effort to combine these reports.

School principals were to complete the form in September, 1987. A follow-up form in June, 1988, reported on end-of-the-year statistics, such as teacher turnover, dropouts, and school test results. The completion rate was near 100%. A spot check of several schools showed forms had been filled out correctly and lent confidence to analyses based on them.

Once the questionnaires came in, data entry technicians would transfer the written answers into computer files. Keying in four thousand pages of data is a tedious job. Project consultants devised data entry screens that could simultaneously check the validity of the data, thus reducing the error rate.

Two individuals became very proficient in querying the system – one was a Ministry employee and the other worked in the Belize

Education Laboratory. The system was adequate for the task of producing the Annual Report on the Status of Education for 1988.

Unfortunately, in subsequent years, the Ministry found it increasingly difficult to distribute the twenty-two page questionnaire which was the basis for the SMS. In the 1988-1989 school year, the Ministry copier broke down, so when new forms were distributed, a copy of the previous year's information was not included to streamline the new year's work. Not surprisingly, the response rate fell sharply. The next year, getting the new forms out was postponed.

Presently, the Ministry of Education is engaged in a World Bank project to establish a Planning Unit in the Ministry. No doubt, a management information system will be a part of that effort. With a Planning Unit in the Ministry, more attention will be paid to gathering information to make choices for the future and assess the tradeoffs entailed. LTP has provided accurate baseline data for the 1987-1988 school year. Moreover,the Belizeans have had the experience of building a school monitoring system, and, with ample funds available, they may exploit the planning and decision making tools now available for computers.

SPEAK AND MATH

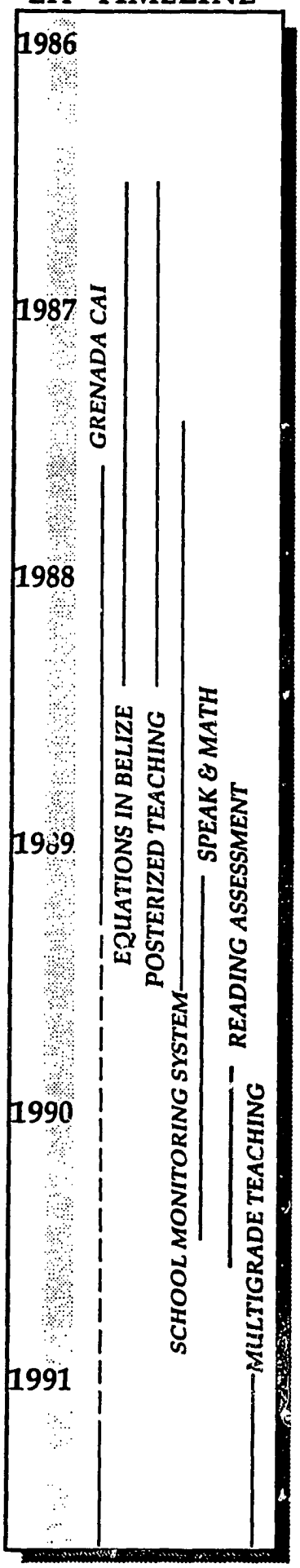
Low levels of mathematics achievement are cause for concern in all educational systems. Low math achievement in rural students are common in developing countries. One reason may be that there are few opportunities for computational practice in arithmetic textbooks. Counting on fingers suffices for the problems presented, and automaticity in addition, subtraction, multiplication, and division is never developed. Skills, never fully developed, are subsequently rarely remediated, and students leave school unable to preform computations demanded by jobs or by market transactions.

In 1989, LTP tested the Texas Instrument Speak and Math in four schools in which performance on the Belize National Selection Examination in mathematics was especially poor. (Four similar schools would act as controls.)

Speak and Math is a one-pound battery operated box that literally speaks the language of mathematics. A microchip generated voice calls out problems and tells a student whether the answer is right or wrong. The numbers in the problems are simultaneously displayed on a screen. The device provides drill and practice exercises in numeration, addition, subtraction, multiplication, division, and some rudimentary word problems.

Speak and Math generates about 100,000 problems, more or less randomly, at three levels of difficulty. Users select the type of problem and the level of difficulty, then Speak and Math presents problems combining visual display with synthesized speech (English). The user punches in the answer at the numeric keypad, and the machine responds "That's correct," or "Wrong. Try again." Once the student has erred twice, the machine responds with "Incorrect. The correct answer is..." It also reports a score for each series of five problems.

LTP TIMELINE



S&T/ED had sponsored a study done by the University of Massachusetts using Speak and Math some five years earlier in rural schools in Lesotho. The outcomes, though in the right direction, were not statistically significant. The researchers suspected that had the devices been used for longer than the four month test period, the results would have been significant. The Belize experiment offered the chance to test that explanation.

About four hundred students in Infant 2 and Standard 1 (second and third grades) worked with the aids for one-half hour daily throughout the school year. They worked in groups of three, taking turns operating the machine or working with paper and pencil. Teachers could then look at the papers to detect difficulties students were having.

The teachers liked the aids, and the students liked the aids. Cultural adaptation to the machine was not a problem. One complaint was that the machine could not explain why an answer was incorrect. (To be fair, almost no math drill and practice software available on microcomputers can do this either!)

Results of this study were very encouraging, for all three grades, students using the learning aids outperformed control students significantly. The impact was similar to raising a typically average student (one performing at the 50th percentile) to one performing at the 68th percentile -- a jump in performance that exceeds about 84% of educational interventions tried in the U.S.

Also encouraging was that learning gains were not concentrated in either boys or girls or in the socio-economic status of the students (although high SES students performed better than low SES students both before and after using the learning aid). Speak and Math seemed to help all students.

SPEAK AND READ

Texas Instruments Speak and Read electronic learning aids were distributed to the three schools for Spanish speaking refugee children from El Salvador taking part in the Radio Learning Project interactive ratio demonstration. Speak and Read, like Speak and Math, uses a computer generated voice and simultaneous screen display; Speak and Read drills letter and word identification and spelling.

The Radio Learning Project was testing first-grade English language instruction tapes first developed in Kenya and modified in Honduras. A pilot project for the "Let's Learn English" programs was conducted from September to December, 1989, in six classes.

The Speak and Read devices were added to three of the six schools to see if the children could benefit from the devices and whether there was any advantage to using the devices in combination with the radio English lessons.

The informal results from this small trial of Speak and Read were encouraging, although no firm data were generated. What was most encouraging was the decision of the Curriculum Development Unit (CDU) to conduct another trial of Speak and Read on their own.

In 1991, the CDU studied the use of Speak and Read in three schools with Spanish speaking children. Peace Corps volunteers assisted in this four and a half month investigation. CDU's report concluded, "Clearly from the results of the post-test, the Speak and Read programme could be very effective in providing ESL learners the necessary skills required for effective learning of a new language -- English, as well as some readiness skills as beginning readers.

One indirect indicator of the Speak and Read's popularity was the complaint that having only one aid for two students was not sufficient. The three schools wanted to continue using the devices when the trial was complete; in one school the parents agreed to pay for the cost of batteries.

At the writing of this report, the devices are still being used in the schools.

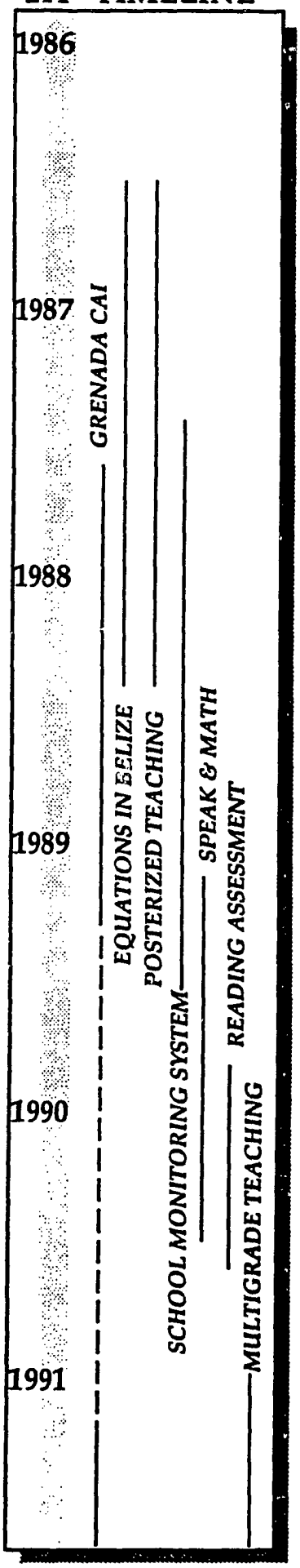
READING ASSESSMENT

In early 1990, the Belize Education Laboratory and the Ministry of Education worked out an agreement to conduct a study of reading skills in Belize using a computerized diagnosis instrument. The outcome would provide curriculum planners with which specific reading skills were and were not being mastered by students and grade level. Curriculum planners could then design materials to remediate these reading deficiencies.

LTP worked with the Laboratory for the Assessment of Language Skills at the University of Massachusetts (UMass) to carry out this project. UMass consultants used two instruments to assess the reading skills of the Belize students. One instrument measured general comprehension skills; the other instrument measured cognitive skills required for the task of reading.

Listening and reading comprehension tests, based on Standard 1 (third grade) and Standard 4 (sixth grade) curriculum materials, were developed by UMass and reviewed by Belize officials. These comprehension tests were based on the Sentence Verification Technique, developed by UMass and used for the LTP evaluation of the WICAT courseware in Crochu, Grenada. Interestingly, during test development, UMass consultants suspected that the curriculum

LTP TIMELINE



designated reading material for Belize seemed difficult for that age group, given their U.S. experience.

UMass had developed a computer-based reading diagnostic system (Computerized Reading Analysis System, CRAS) that assessed the speed and accuracy of letter identification, word identification, pseudo word identification (e.g. cark: this task assesses phonetic encoding skill), concept activation, syntactic analysis, and semantic analysis. Using this instrument, researchers can identify the component skills that have not developed to the point necessary to support skilled reading.

Thirty-four Standard 1 and forty Standard 4 students from three schools were tested as a group with the sentence verification technique then individually using the CRAS battery on a laptop computer.

The results from the listening and reading tests (the sentence verification technique) indicated that Belize students were having difficulty understanding the materials the tests were based on. Such results provided evidence that helped confirm previous suspicions that the Belize reading curriculum may be too demanding of students at certain levels.

For comparison's sake, the CRAS battery data was compared with U.S. students, however, the U.S. students were a sample of at- or above-grade level readers for grades 3, 4, 5, and 6. So, the comparison of Belize students is against better U.S. readers.

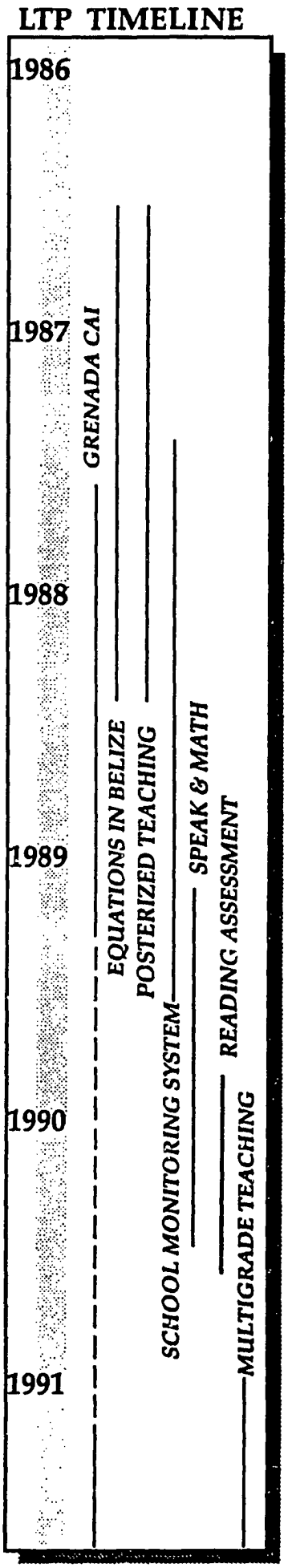
Performance on the lowest level task (simple reaction time) showed Belize students substantially slower than U.S. students. Researchers attributed this to lack of familiarity with computer tasks.

Other results indicated that the average Belize reader was considerably less skilled in low level reading skills such as letter recognition, word recognition, and word attack skills. In higher level skills, (concept activation, syntactic analysis, semantic analysis of sentences), Belize readers were closest to U.S. counterparts. Nonetheless, the average Belize reader was approximately two years behind in skill development relative to at- or above-grade level U.S. readers.

Variation in performance between school was marked. One school's readers performed on a par with U.S. readers; the two other schools showed a much greater disparity.

Belizean Ministry Officials found the results both interesting and informative. The Ministry may find these findings especially useful as the cycle to revise the reading curriculum comes up again in several years.

On a broader note, the CRAS system has potential utility in countries other than Belize. Currently, the system, with training, can be used with reasonable ease by education personnel in developing countries. A Spanish version of CRAS has been developed, and versions using other languages could be developed relatively simply.



SECTION 3: LINKAGES AND CONTRIBUTIONS

1985

Project staff participated in a panel entitled "Literacy, Education, and Public Policy: International Perspectives," at the International Conference on the Future of Literacy in a Changing World. The discussion centered around policy-oriented researchers from Latin America and Asia. LTP's contribution was documenting A.I.D.'s previous experience using hand-held learning aids in Lesotho.

S&T/ED hosted three student interns from Worcester Polytechnic Institute in Worcester, Massachusetts. During the Fall term, these interns organized an Educational Software computing center at S&T/ED. All software was tested, evaluated, and catalogued. The room was used for almost two years to demonstrate software to interested visitors.

1986

Through LTP cooperation with the Communications Support Project, funding was arranged for technical assistance to a World Bank project planning effort in Nepal. The World Bank requested LTP help in identifying technical assistance for designing a computer lab for remedial education of engineering students entering the technical university.

Project staff attended a Unesco symposium at Stanford University on "Computers in Education: The Role for International Research." The meeting discussed the direction of possible applications for computers in developing countries and what research would guide those efforts.

Project staff travelled to Puerto Rico to help the Ana Mendez Foundation in planning the establishment of the Caribbean Institute for Computer Sciences.

IIR hosted three student interns from Worcester Polytechnic Institute in Worcester, Massachusetts. During the Fall term, these three interns wrote a document to inform decision makers about the possibilities of using microcomputers and other learning technologies in their school systems. The paper was distributed

to interested A.I.D. education officers and Ministry of Education Officials.

1987

LTP and S&T/ED representatives presented a discussion panel on the work done thus far in the LTP for the Comparative and International Education Society 31st Annual Meeting.

Control Data, in a small grant to IIR staff, funded a paper which outlined a methodology for determining and comparing educational costs in developing countries. Control Data was interested, particularly, in finding niches where educational costs were typically high and computer assisted learning could be justified more easily.

The presentation documenting A.I.D.'s experience in Lesotho with the hand-held learning aids in an earlier conference on literacy was published as a chapter in The Future of Literacy in a Changing World, edited by Daniel Wagner and published by Pergamon Press.

A project report, "Computer Classroom Ethnography" by Carla Freeman provided a snapshot of the experience at Crochu in Grenada as an case study. The study illuminated, from an anthropological viewpoint, how rural teachers and students alike were coping with the demands of sophisticated technology.

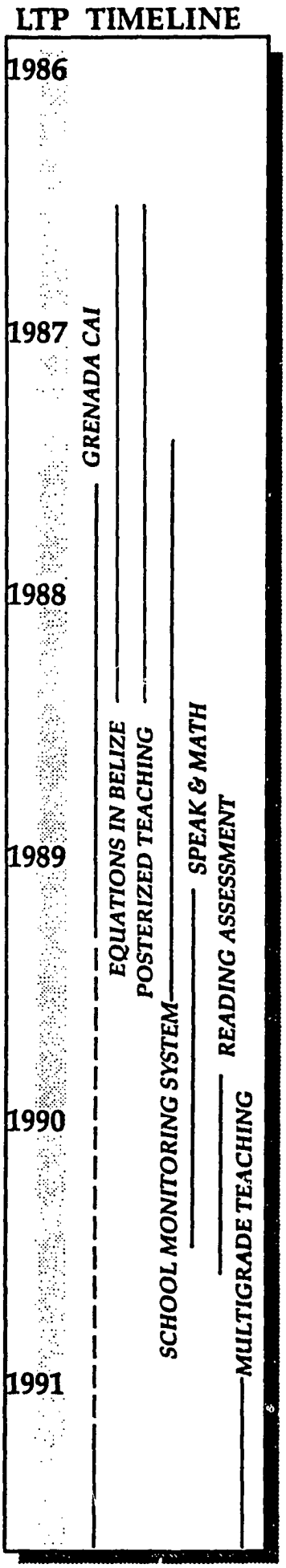
The project director was asked by Control Data in the Caribbean to interpret and evaluation done by the University of the West Indies on the effect of PLATO instruction on Basic Skills in Jamaica. His analysis showed that a gain of over one standard deviation was achieved by the PLATO instruction, as compared with gains half that great in instructional radio, for example.

Control Data approached A.I.D. with an unsolicited proposal to establish a multi-purpose computer facility to remediate secondary school learning and provide community college courses in St. Georges. Control Data, in a bold cost proposal, made reimbursement contingent on performance. Had the project been funded, the effort would have been evaluated under LTP auspices.

IIR, independent of LTP but continuing the commitment to using technology to address education and training needs in Belize, worked in association with ALTA Associates to submit a proposal to the Office of the Science Advisor. IIR/ALTA proposed using interactive compact disc technology to develop management training courses for the Belize Institute for Management. The proposal was not funded.

1988

The project director was invited to participate as a consultant to work with participants at a seminar on "Using Technology for Education and Training," sponsored by the Economic Development Institute of the World Bank.



The Institute of Mathematical Studies at Stanford University submitted an unsolicited proposal to the Bureau for Science and Technology to use microcomputers to teach grades 1-8 mathematics in urban elementary or junior secondary schools. The idea was to test a "critical intervention" hypothesis, essentially that technology with individual performance management can bring students to grade level despite poor preparation in prior grades. Moreover, the gains made through the intervention will be sustained in subsequent schooling or job performance. The project and the S&T/ED pressed for acceptance with the Deputy Administrator, but funds were not forthcoming.

BRIDGES asked the LTP director to compile a review of research entitled, "Using Instructional Hardware for Primary Education in Developing Countries." The document was disseminated through BRIDGES.

LTP and the Belize Education Laboratory supported a pre-proposal by Friend Dialogues to the Office of the Science Advisor in A.I.D. Friend Dialogues proposed developing software to be used in an intelligent electronic learning aid. The Belize Education Lab would test the software. The proposal reached the final round of consideration but was not funded.

1989

As a part of the North American Education for All Regional Forums, the project organized an exhibit entitled "Promoting Learning and Literacy through Multi-media Technology." The presenters were Apple Computers and IBM Educational Systems. The project also organized a roundtable discussion entitled "New Delivery Systems for Basic Education."

The LTP project director wrote a paper for the World Bank, examining implementation issues of educational technologies over all levels of education. The document, which was entitled "Educational Technology and the Improvement of General Education in Developing Countries," would later appear in the publication Educational Technology: Sustainable and Effective Use that was edited by Marlaine Lockheed, John Middleton, and Greta Nettleton.

Papers were presented at the annual meeting of the American Educational Research Association. Dr. James M. Royer and

colleagues at the University of Massachusetts made presentations on the sentence verification technique used in Grenada and on the results of the Grenada study in general.

1990

At the World Education for All Conference in Jomtien, Thailand, LTP staff coordinated arrangements for the A.I.D./IDRC thematic roundtable discussion, "Greater Access to Better Quality; Distance Education for Primary School Improvement." Staff collaborated in writing the script for the videotape "Distance Education: Bringing more, Reaching More." LTP staff also arranged for a live simulation of an interactive ratio lesson involving Thai school children.

An article published in the International Review of Education, 36(1),"A New Technique for Measuring Listening and Reading Literacy in Developing Countries," by Barbara Green, James Royer, and Stephen Anzalone. This article reported on the Sentence Verification Technique that allows reading and listening tests to be developed relatively easily in any culture. The study was done in Grenada.

A project document, "Computers in the Classroom: A Cost Analysis Kit," by Peter Glick, Michael Rock, and Ronald Sprout was published. A background paper specified what exactly the costs of operating microcomputers were in the Belize secondary schools and detailed the various ways each school paid for their microcomputer setup. The kit gave explanations of cost categories, examples of case studies, and a Lotus 1-2-3 spreadsheet template for practitioners in developing countries to construct their own cost analyses.

Project staff presented project findings and general background of the uses of educational technologies at an A.I.D. workshop on "Basic Education in Africa: Lessons Learned" in Lome, Togo.

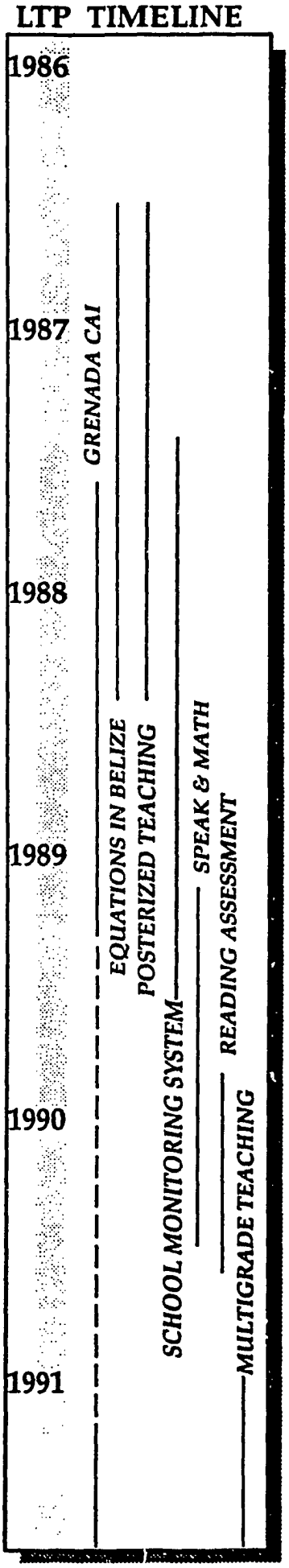
LTP staff contributed two articles to S&T/ED's publication, Lessons Learned in Basic Education in the Developing World. These were "Computer Assisted Instruction and Basic Skills Improvement" and "Low-cost Electronic Learning Aids."

An article, "Speak and Math: Learning Electronically in Belizean Schools" by Pornjit Arunyakanon appeared in the Development Communication Report.

1991

A project report, "Computer-Based Instruction: An Up-Date of the Recent Literature" by James Royer and Cheryl Cisero was submitted. Learning outcomes with CAI are not differentiated by gender, but younger students do seem to benefit more from CAI as do students of lower ability (though this result may be an artifact of the student populations tested).

Project staff assisted the U.S. Coalition for Education for All in organizing the "Mobilizing Media in Support of Education" in support of the conference, "Learning for All: Bridging



Domestic and International Education," held in Washington. The project director wrote the Conference's issues paper on media and organized the plenary session on media and six discussion panels.

The International Journal of Education Development 11(1) featured an article, "A Cost Analysis of Computer Instruction in Belize," by Michael Rock, Peter Glick, and Ronald Sprout. The article looked at how computer instruction is financed in Belize and how it affects educational costs. The most encouraging finding was that high costs to school providers were reduced by a wide array of cost recovery measures.

The Fall issue of the Development Communication Report featured the Learning Technologies Digest. About fifty requests for the hypertext program came in. Currently, the Learning Technologies Digest is available through Advancing Basic Education Literacy Project (ABEL).

A LearnTech/LTP seminar featuring Sandia National Laboratory and Oak Ridge Associated Universities on photovoltaic technology was held at IIR during July. Presenters introduced the principles of solar energy design and provided examples relevant to educational applications in developing countries.

The project director received an invitation to a conference on the Use of Technology to Support Adult Literacy at the National Center of Adult Literacy, at the University of Pennsylvania.

In conjunction with the study of electronic learning aids in Belize, a student from the School of Education at the University of Pittsburgh, Pornjit Arunyakanon, was able to gather additional data leading to a doctoral dissertation. The dissertation, The Effects of Hand-held Electronic Learning Aids and Cognitive Style on Mathematics Achievement of Primary School Achievement in Belize followed an "aptitude treatment interaction design."

An article will soon be published in the Journal of Educational Computing Research (in press), "Can U.S. Developed CAI Work Effectively in a Developing Country?" by James Royer, Barbara Green, and Stephen Anzalone. This article reports on the evaluation of the computer-assisted instruction in Grenada.

LEGACIES

LTP is proud of having been able to provide opportunities for, and to learn from, four young people who are likely to become educational leaders of tomorrow, particularly in the area of educational technology and media.

Carla Freeman, a doctoral student at Temple University, is currently completing a dissertation on lives of women in data entry centers in Barbados. The dissertation is being supported by the National Science Foundation and Fulbright Fellowship. Carla completed the classroom ethnography of computer learning at Crochu.

Leroy Almendarez, because of his work on developing the School Management System, became one of the most knowledgeable computer professionals in Belize. When he completes his graduate program in Canada, Leroy is expected to go to the faculty at the University College of Belize.

Pornjit Arunyakanon assisted project activities in Belize and Grenada. She also helped prepare for the Jomtien conference in her native Thailand. During the project, she completed her dissertation on the use of electronic learning aids in Belize. Dr. Arunyakanon will head a new college expected to open in Bangkok in 1993.

Kit Schrichte has been working on various LTP and LearnTech activities at IIR. In the fall, she is expected to begin graduate studies in instructional design and educational media. She hopes to combine her LTP experience with her television and theatre background to become a part of the educational development community in interactive educational technology.

APPENDIX A: BACKGROUND ON BELIZE

A former British colony, Belize is a small country of some 180,000 inhabitants situated south of Mexico on the Gulf.

About 58% of the population is under the age of nineteen. The main ethnic groups are Creoles, Mestizo, and Garifuna. English is the official language of government and education. Spanish, however, is widely spoken.

The educational system is heavily influenced by British structure. Some schools admit students at the Kindergarten level (age five); other admit them into Infant 1 (the equivalent of grade 1 in the U.S. system). Infant 2 is followed by Standard 1 (grade 3), and students proceed up to Standard 6 (grade 8). At the end of Standard 6, students sit for the Belize National Selection Examination (BNSE), that is used to provide certification for completion of primary school, to determine admission to secondary school, and to select students for government scholarships.

Schools in Belize are run through government/church collaboration. Various religious denominations manage the majority of the schools. The schools are run under a decentralized system that is specially funded by the state.

Primary school education is compulsory for children between the ages of six and fourteen. Primary education is free. Students and their families are required to pay for secondary education and beyond.

Primary education performance statistics in Belize are better than in neighboring countries. The literacy rate is almost 93%. The dropout rate for primary school is almost insignificant.

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APPENDIX B:
LIST OF NON-ROUTINE REPORTS/PRODUCTS
JANUARY 1992

BELIZE - MATH

- Software Suggestions for Belize (1990)
- Acquisition of Mathematics Skills in a Game Environment: An Experiment in Belize--Summary of the Final Report (1990)
- Boosting Mathematics Achievement With Electronic Learning Aids: The Experience of Belize (1990)
- The Cost Feasibility of Electronic Learning Aids in Belize (1990)
- Speak & Math: Learning Electronically in Belizean Schools (1990)
- Belize Learning Aids Study: Mid-Term Results (1989)
- Acquisition of Math Skills in a Game Environment (EQUATIONS) Final Report - Phase II (1988)
- Acquisition of Math Skills in a Game Environment (EQUATIONS) Final Report - Phase I (1987)
- Improving Mathematical Skills with Electronic Learning Aids: A Study of Rural Schools in Belize - A Proposal
- Project Update: Belize Mathematical Gaming Experiment (1986)

BELIZE - PPTT

- Belize PPTT: Final External Evaluation Report (1989)
- PPTT: Summary of Progress (1989)
- Posterized Programmed Teaching Technology: An experiment in Belize (Draft) (1989)
- Posterized Programmed Teaching Project, Preliminary Evaluation Report (1988)
- Belize PPTT: Final Data Analysis (1988)
- PPTT Teachers Manual
- Low-Cost Learning Systems: Their Implications for the Belizean Posterized Programmed Teaching Project
- PPTT Reading and Social Studies - Pupil's Work Book
- Formative Feedback System for PPTT in Belize: Learner Verification and Revision
- PPTT Guide for Workshop for Instructional Designers (1987)

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- PPTT - Implementation and Evaluation: A Trainer's Guide
- PPTT - Manual for Instructional Designers (1987)
- Research Design: Summative Evaluation of the Posterized Progrmmed Teaching Technology (1981)

BELIZE - SCHOOL MONITORING SYSTEM

- Belize Primary School Monitoring System
- Belize School Monitoring System: User's Guide (Draft) (1988)
- Belize School Monitoring System: Plan of Action for Second Phase (1988)
- School Monitoring System for Belize: A Proposal (1986)

BELIZE - SURVEY

- Open Ended Questions on Belize Survey (1986)
- Belize Primary Education Needs Survey: Preliminary Analysis of Priorities (1986)
- Preliminary Analysis on Belize Survey Results (1986)

DISTANCE TEACHING

- Distance Education: Bringing More, Reaching More (1990)
- Status Report on the Distance Teaching Terminal Activity (1986)
- The Design and Evaluation of an Integrated, Distance Teaching Terminal - A Proposal (1984)

GRENADA CAI

- Can U.S. Developed CAI Work Effectively in a Developing Country? (1990)
- A New Technique for Measuring Listening and Reading Comprehension in Developing Countries (1990)
- Computer Assisted Instruction and its Effects on Primary School Achievement in Grenada (1989)
- The Sentence Verification Technique for Measuring Comprehension in Grenada (accepted for presentation at the 1989 AERA annual meeting)
- An Evaluation of the Effects of Computer-Assisted Instruction on Student Achievement in Grenada (1988)
- Grenada Primary School Achievement Test - Levels 1, 2, 3, 4, 5
- A Multiple Use Computer-Based Education Center for Grenada (1987)

- Grenada Computer Classroom Ethnography (1987)
- A Proposal to Evaluate CAI in Grenada (1986)

OTHER

- Final Project Report (1992)
- Will the First Wave Meet the Third Channel? (1991)
- Learning Technologies Project - Evaluation Report (1991)
- Between Active and Interactive Instruction: Options for Basic Education in Developing Countries (1991)
- Mobilizing Media in Support of Education (1991)
- Tough Questions for International Literacy Year (1990)
- Computers in the Classroom: Cost Analysis Kit for Developing Countries (1990)
- Microcomputers for Basic Education in Developing Countries: Four Examples (1990)
- Cost Analysis of Computer Usage in Education in Belize (1989)
- Learning Technologies Computerized Information Digest (1988)
- Learning Technologies Project: Pilot Research Studies on Learning Technologies - Call for Pre-Proposals
- Educational Costs in Developing Countries: What We Know and Don't Know (1988)
- Alternative Learning Technologies and Educational Policy Goals in Developing Countries (1988)
- Learning Technologies Project: Status of Activities (1988)
- Measuring Reading Comprehension in Programs Using Instructional Technology: A Low-Cost Approach for Developing Countries (draft) (1988)
- A.I.D. Learning Technologies Project: An Agenda for Action (1987)
- Final Report: Spacebridge/AID/LTP/World Bank Project for Establishing Telecommunications Link to World Bank/EDI Seminar (1987)
- The Effects of PLATO Instruction on Basic Skills in Jamaica: An Analysis (1987)
- The AID Learning Technologies Project: Work in Progress (1987)
- Micros in Education: Three Studies for Belize (1987)
- Interactive Compact Disks (CDI): Investigating the Feasibility of Low-Cost Approach Applications for LDCs (1987)
- Efficient Low Cost Teaching/Learning Materials (1986)

- Microcomputer Studies (1986)
- Project Update: The Belize Education Laboratory (1986)
- Implementing Learning Technologies in Third World Education (report from student interns) (1986)
- Memorandum of Agreement between the Government of Belize and the Government of the United States of America Represented by the Agency for International Development for a Program of Studies in Educational Technology (1985)

APPENDIX C: LTP ADVISORY PANEL

Tryg Ager
Stanford University
Stanford, CA

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Johns Hopkins University
Baltimore, MD

Jay Blanchard
Arizona State University
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Geoffrey Davis
ISC Educational Systems, Inc.
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