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TECH REPORT

THE DEVELOPMENT AND IMPLEMENTATION OF A MODEL FOR THE DESIGN OF INDIVIDUALIZED INSTRUCTION AT THE UNIVERSITY LEVEL

James Gary Lipe

Tech Report No. 15
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This study involved the development and implementation of the Production, Implementation Evaluation and Revision of Instructional Modules (PIERIM) model for the design of individualized instruction. PIERIM is designed as an interactive model with activities explicitly prescribed for the instructor and the educational technologist. PIERIM's purpose is to provide a means by which the content of existing teacher training programs can be transformed into a format (i.e., instructional modules) which is compatible with an individualized teacher training program.

The PIERIM model was compared with two other system models for the design of instruction (Briggs, 1970; & Dick, 1969) on the basis of assumptions upon which the model is based, personnel required to implement the model,

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PIERIM was implemented for a portion of an elementary education course: three weeks of traditional instruction was converted into 25 instructional modules. The modules were implemented in a conventional classroom environment (N=19), revised on the basis of learner performance, and then implemented in a self-instruction environment (N=28). The pre-and posttest performances of the two groups were approximately equal.

An instructional Support System (ISS) was designed to support the implementation of the instructional modules in the self-instruction environment. Four ISS computer programs, written in FORTRAN IV, produced the instructional modules, tests, and summaries of learner performance. It was also demonstrated that the programs could be used to produce modules for a similar course, educational psychology.

A single index, the Revision Indicator, was developed which ranked the set of instructional modules on their relative need for revision. Two sets of Revision Indicators, derived from the performance data, identified the same three instructional modules as most needing revision. Rank order correlation between the two sets of Revision Indicators was $r_s = .83$.

Faculty members from Elementary Education and Educational Research ranked the instructional modules on the basis of the relative importance of a teacher candidate being able to demonstrate the behavior described by the modules. Rank order correlation between the two sets of rankings was .71 for the total set of modules. Faculty members indicated that if they were to teach the course, the set of modules would represent approximately 60 percent of the evaluation unit.

Based on experience gained through implementation of the model, the activities were evaluated and PIERIM (2nd edition) represents an operational definition of the job descriptions for the instructor and educational technologist. The major identified weakness of a set of instructional modules produced by the PIERIM model remains: the relevance of the set of instructional modules, when compared to a specific teacher competency, cannot exceed the relevance of the subject matter from which the modules were derived.

The estimated cost of designing and producing 28 sets of the instructional modules and tests was $768.52, with design and production costs representing 83 percent and 17 percent of the total, respectively. Designing and testing the ISS computer programs cost an additional $434.00. Based on the eight classroom hours devoted to the implementation of the modules and tests in the self-instruction environment, the development cost is approximately $150 per hour of instruction. In order to estimate the cost of implementing PIERIM with faculty members rather than graduate students, the personnel costs were doubled and the resulting estimate was $230 per hour of instruction. Utilizing the $230 estimate, PIERIM could be implemented and the contents of an education course (i.e., 30 class hours) transformed into instructional modules and tests for use in a self-instruction environment for approximately $6,900.

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The PIERIM model was compared with two other system models for the design of instruction (Briggs, 1970; & Dick, 1969) on the basis of assumptions upon which the model is based, personnel required to implement the model, intended level of application, level of analysis, and activities required to implement the model.

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CHAPTER I

INTRODUCTION

Saettler (1968) traced the history of instructional technology and placed 1960 as an approximate date for the use of the phrase "total systems approach" to describe the interaction of men, machines, and resources within the context of an organization in terms of specific tasks and outcomes. Ryans (1964) discussed the importance of viewing education as a system and presented a research approach to system study and design in the planning of higher education. Recent developments in teacher education demonstrated the necessity for viewing the preservice professional component of a program as a subsystem of higher education.

LaGrone (1964), in a proposal presented to the American Association of Colleges for Teacher Education for the revision of the preservice professional component of a program of teacher education, stated:

> The current instructional materials will not meet the demands of the proposed professional curriculum . . . . To realize the potential of the proposed content outline new materials that capitalize on the concept of an instructional system approach will be needed. A task of this magnitude would be difficult but far from impossible (p. 60).

Silberman and Carter (1965) described the deficiencies in the present education system and concluded that "prospective teachers are not taught to take pride in using and evaluating instructional tools that are effective in producing desired student behavior (p. 73)."

Engbretson (1969) conducted an analysis and evaluation of plans for comprehensive elementaty teacher education models submitted to the U. S. Office of Education (USOE), and provided the following chronology of events:

August, 1967--A meeting at which the possibility of funding the elementary teacher education models was discussed was held in Washington, D. C.

October, 1967--Request for proposals was issued by USOE.

January, 1968--Eighty proposals were received in response to the request from USOE.

February, 1968--USOE convened an evaluation panel which considered over twenty proposals and recommended funding of twelve models. Nine of the twelve models were funded by the Bureau of Research to conduct feasibility studies.

Clarke (1969) reviewed the major features of the nine funded proposals and made the following comments concerning the models proposed by:

1. Florida State University--"The program calls for staff development for the staff of the teacher education institution in such areas as programmed instruction . . . individually prescribed instruction, multi-media and simulation techniques (p. 287)."

2. University of Georgia--"Detailed performance characteristics are specified, but corresponding materials, treatments, etc., designed to develop each characteristic are not included (p. 288)."

3. Michigan State University--"The program anticipates the widespread use of pupil 'instruction material packages' (p. 290)."

4. University of Pittsburgh--"'This is a training model for individualized instruction. The program will use individualized instruction to prepare teachers in order to facilitate individualization of instruction within any school' (p. 290)."

Silberman and Kooi (1969) described a generalized model based on their analysis of the nine funded model proposals. Their generalized model includes sets of specifications for: (1) curriculum modules, (2) student flow and (3) support systems. A curriculum module is defined to consist of a single objective. The time required to complete a module is considered to be dependent upon the task(s) involved and the strengths and weaknesses of each individual trainee. Within the support systems, the program support system is used to design, construct, and test instructional modules, and to handle the logistics of the program. In discussing the support system, Silberman and Kooi (1969) stated:

> Only a few of the models consider cost factors for support systems. Pittsburgh estimated that it would cost $804,000 to develop materials, and would require 20 hours of retraining per staff member. They also estimated that they would need one additional staff member per 50 students, and 50 more square feet per pupil (p. 7).

The specification of objectives for the models were concluded to be: (1) neither specific enough nor operational enough to be implemented without further definition, (2) derived from or compatible with the present course structure in the better teacher-training institutions, and (3) derived from content analysis rather than an analysis of what it takes to change pupil behavior (Silberman & Kooi, 1969).

C. Lange (1968) concluded that "in order to introduce changes in teacher education, it is likely that programs of instruction must be developed to achieve specific sets of objectives . . . (p. 16)." Smith, Cohen, and Pearl (1969) stated the problem in a slightly different manner:

> There is now no set of training situations available to teacher educators. There are lists of objectives, tests for assessing the cognitive achievement and attitudes of trainees, and scales of rating their teaching behavior. There are all kinds of pretentious models for teacher education. But there are no materials to be used in actually training the teacher . . . (p. 77).

The paradox of teacher educators talking about and advocating individualized instruction and yet failing to individualize the teacher education programs was noted by Carr (1962) in the early 1960's, and Yee (1969) continued to appeal for the individualization of teacher education programs. Progress toward individualization of teacher education programs has been indicated by Monson's (1969) conclusion that a common element of the nine elementary teacher models is "greater stress on individualization . . . (p. 101)." Esbensen (1968) and Baird, Belt, and Holder (1968) described teacher training programs which have been individualized at St. Scholastica College and Brigham Young University, respectively.

In summary, new models for programs of teacher education continue to be developed and discussed (LeBaron, 1969b) and one problem area, if not the major problem area for educators concerned with the development of individualized preservice programs of teacher education, appears to be related specifically to the program support system described by Silberman and Kooi (1969). The functions of the program support system include the design, production, and testing of instructional modules and the handling of the program logistics.

Research Methodology and Procedures

There is a growing awareness that educational researchers must consider research methodology and procedures which differ significantly from traditional methods. Some of the leading educational researchers are reconsidering the entire field of educational research and the relationships which exist among the developing research designs and traditional research designs.

Recent statements of the National Academy of Education (Cronbach & Suppes, 1969) provide support for departing from the traditional research design:

> Too many writers seem to limit the term "research" to quantitative empirical inquiry . . . The study of education requires non-quantitative as well as quantitative techniques (p. 14).
>
> Decision-oriented "product research" is part of an effort to develop an educational procedure that can be followed systematically in the future, ordinarily in many localities. Such product research is often called "development" (p. 27).
>
> Developmental research is untidy. It is disciplined, in that the investigator is expected to be systematic, so that other qualified persons can follow his reasoning. But the process is one of reacting rationally to the unexpected. Though the innovator may be sure what general form his product will take, he will soon find himself deep in problems that call for engineering studies, inventions, or fundamental scientific inquiry (p. 174-5).

The research procedures can also be classified under the original meaning of action research that Travers (1962) attributes to Kurt

Lewin: "research in a real-life situation in contrast to research within a laboratory . . . (p. 542)." Travers (1962) concluded that:

> There is a need to develop miniature theoretical systems related to events in the classroom, and perhaps this type of exploration is more urgently needed than attempts to apply current learning theories to classroom situations . . . (p. 555).

Within Scriven's (1967) categories of process research, this study would be classified as formative evaluation. Formative evaluation is designed to discover deficiencies and successes in intermediate versions of instructional materials.

Stake and Denny (1969) addressed themselves directly to the problems of research as it applies to the design and evaluation of instructional materials. They expressed the hope that:

> . . . individual researchers will attempt to produce needed analytical techniques to assess the structure and coverage of the content of instructional materials as well as to produce performance criteria for evaluating the behavior of users of such materials under a variety of specifiable conditions of use (Stake & Denny, 1969, p. 379).

Statement of the Problem

The present study consisted of three separate but related parts:

1. A model for the Production, Implementation, Evaluation, and Revision of Instructional Modules (PIERIM) was designed and a detailed non-empirical comparison between PIERIM and two existing system models for the design of instruction was presented.

2. The implementation of PIERIM for a portion of an undergraduate elementary education course was conducted in order to determine: (a) the feasibility of implementing the model, (b) job descriptions for the participants of the implementation, (c) cost estimates in terms of

time and materials required to implement the PIERIM model, (d) evaluation of student performance when utilizing instructional modules produced using the PIERIM model, and (e) recommendations concerning the contents of training materials that could be used to develop the skills identified for the participants in the implementation.

3. Development of an Instructional Support System (ISS) which utilized existing technology to support the implementation of the PIERIM model. The ISS development was analyzed to determine: (a) elements required in an ISS, (b) adequacy of the ISS as measured by the output of the system, and (c) cost estimates in terms of time and materials required to implement the ISS.

Significance of the Study

The significance of this study is in the development and evaluation of the PIERIM model for the design of self-instructional modules. The PIERIM model provides educators with an alternative system model for the design of instruction which is specifically designed to minimize the number and complexity of new skills or tasks initially required to be performed by the participating instructor. The PIERIM model is a selection model as contrasted to the design models for development of instructional materials.

The study did not attempt to compare the actual development of instruction using each of three selected models, but did compare the similarities and differences in procedures, as defined by each model. The detailed comparison of the models provides educators with some of the questions which should be asked of any model selected for the design of instruction. The detailed job descriptions that were prepared for each member of the implementation team were refined and the PIERIM model was revised on the basis of experience gained through implementation of the model.

In summary, the study: (1) adds to existing bodies of knowledge (e.g., models for the design of instruction and instructional support systems); (2) provides an alternative model, PIERIM, for the design of instruction; (3) provides an instructional support system capable of supporting the implementation of the PIERIM model; and (4) is topical in relationship to USOE's interest and support of the design and implementation of models for elementary teacher education training programs.

Of particular interest to educators at small colleges, junior colleges, and public schools is the development and implementation of an Instructional Support System (ISS) which utilized existing technology to support the implementation of a system model for design of instruction. Each part of the study, and the study in toto, is of specific interest to and provided new knowledge for those persons and institutions which are interested in the use of system models for the design of instruction and the design of instructional support systems to support the implementation of the models.

CHAPTER II

SURVEY OF LITERATURE

The design and implementation of a model for design of instruction requires that the researcher must be aware of the current research efforts in a large number of related areas of research.

The current efforts in the field of curriculum are reviewed for the purpose of defining a curriculum. The implementation of the PIERIM model results in the production of a set of instructional materials for a specific content area. Having defined a curriculum, it will be possible to determine if the instructional materials produced through the implementation of the PIERIM model constitutes a curriculum for the content area. The existence of a curriculum and/or a set of instructional materials implies that there exists an instructional system in which to implement the materials. By defining an instructional system and reviewing the subsystems which comprise the instructional system, the PIERIM model and the Instructional Support System can be related to a more general model of an Instructional System.

The learners who interact with an instructional system can have their performance evaluated either by the use of norm-referenced measures or criterion-referenced measures. Mager's (1962) definition of behavioral objectives has as one of its elements that a standard of performance must be included. The use of behavioral objectives combined with the intended use of the instructional materials in an individualized instruction program dictates that the mastery model and criterion-referenced measures are both specifically related to the PIERIM model. By defining formative evaluation and discussing its application to the evaluation of learners, behavioral objectives, test items, instructional materials and learning environments, it is possible to discuss the relative strengths and weaknesses of the evaluation procedures used during the implementation of the PIERIM model.

The stated purpose of the PIERIM model is to design instructional materials which can be used to support an individualized teacher training program. The research related to individualized instruction and instructional packages is directly applicable to the design and implementation of the PIERIM model. An individualized program of instruction requires greater use of the educational technology that is currently available to educators. Specifically, applications of computers and the use of audio tapes are applicable to the Instructional Support System which is designed to support the implementation of the PIERIM model.

Innovations in education are reviewed in order to identify potential obstacles to the implementation of the PIERIM model in a teacher training program and to place the current efforts in the field of system models for design of instruction into a chronological perspective.

Current Interest in Curriculum

Representative of the current interest and emphasis on the entire field of curriculum are: (1) a discussion of the problems of curriculum evaluation by Tyler, Gagné, and Scriven (1967); (2) a book of readings related to the curriculum of the public schools by Short and Marconnit (1968); (3) an issue of Review of Educational Research entitled Curriculum, edited by Popham and Baker (1969); and (4) major portions or entire issues of professional journals devoted to problems of curriculum (Educational Technology, 1970a, 1970b; Phi Delta Kappan, 1970).

Tyler (1970) pointed out the wide range of definitions and views associated with the term curriculum that are currently in use by educators. From the current definitions of curriculum, Gagné's (1967) operational definition of curriculum was selected for use in connection with the study:

> A curriculum is specified when (1) the terminal objectives are stated; (2) the sequence of prerequisite capabilities is described; and (3) the initial capabilities assumed to be possessed by the student are identified (p. 23).

Instructional Systems

The definition of an instructional system was derived by combining Corey's (1967) definition of instruction and Ryans' (1964; 1965) definition of a system. An instructional system is defined as an identifiable assemblage of complexly organized elements which are:

1. Interrelated by process and/or structure.
2. Interdependent.
3. United by a common information network.

4. Characterized by a regular and orderly form of interaction.

5. Able to function as an entity to enable the learner to emit or engage in specified behaviors under specified conditions or as response to specified situations.

There does not exist in the literature an agreed upon set of elements or subsystems which comprise an instructional system. The most common subsystems discussed can be classified within the following scheme:

1. Design/Selection of Instructional Materials Subsystem provides for the acquisition of instructional materials (Bratten, 1969; Deterline, 1968; Flanagan, 1969; Johnson, 1967; Silber, 1970).

2. Implementation Subsystem provides the environment and procedures for the interaction between the learner and instructional materials to occur (Deterline, 1968; Johnson, 1967; P. Lange, 1968; Ryans, 1964; Silvern, 1968; Smith, 1966).

3. Evaluation Subsystem provides the means by which changes in other subsystems can be measured (Flanagan, 1969; Johnson, 1967; Silberman & Filep, 1968; Tyler, 1951).

4. Revision Subsystem provides the decision structure for identifying elements or subsystems which are not performing at a predetermined level of performance (Silberman & Filep, 1968; Smith, 1966).

5. Information Management Subsystem provides records concerning the performance history of other specified subsystems (Bratten, 1969; Cooley & Glaser, 1968; Flanagan, 1969; Smith, 1966).

The five subsystems are considered to define a larger instructional support system (ISS). The relationship among the preservice teacher education system, instructional support system and the instruction system are shown in Figure 1.

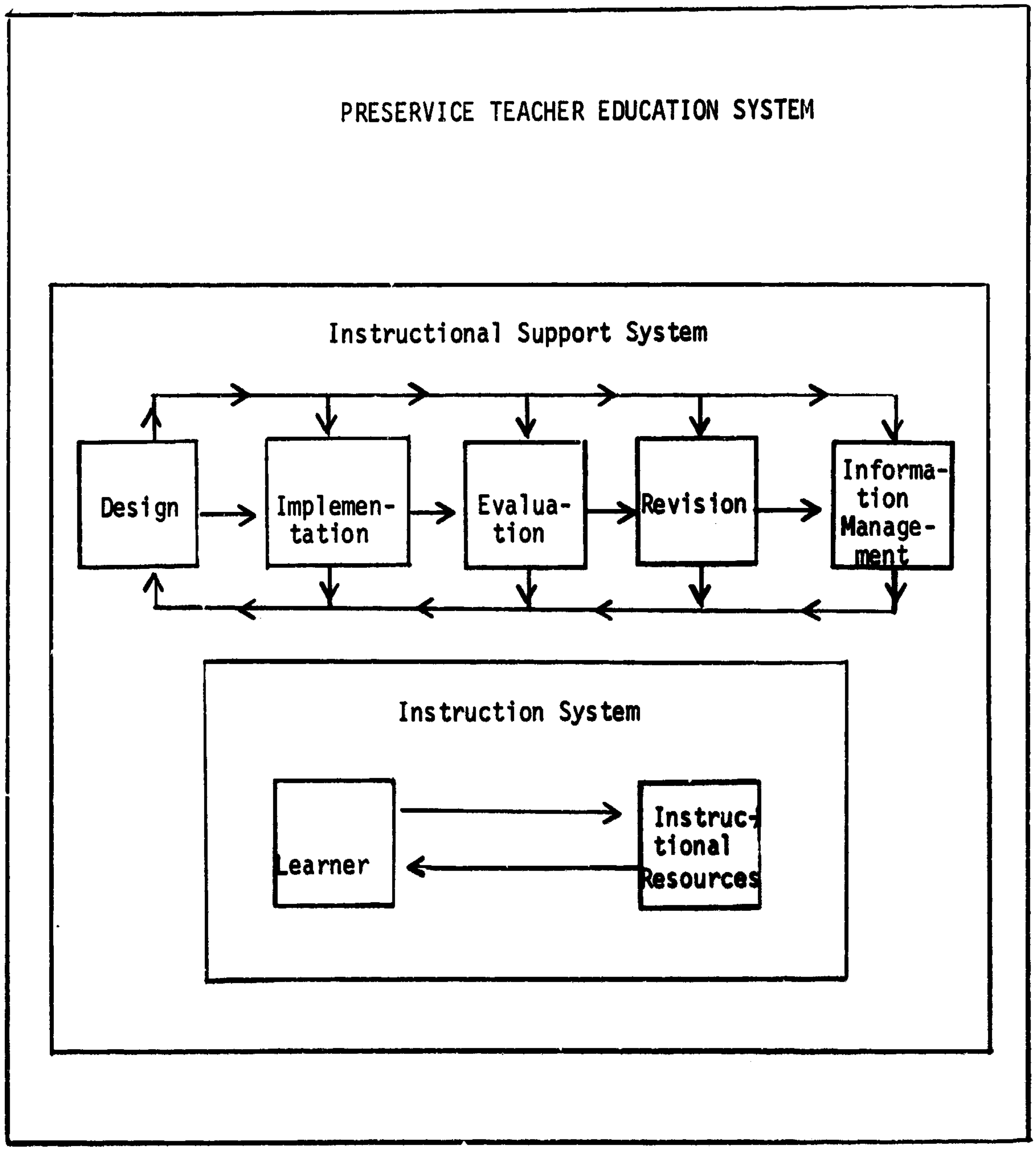


Fig. 1.--Educational systems under consideration

System Models for Design of Instruction

A system model for design of instruction must include at least the following procedures in the order indicated:

1. State behavioral objective.
2. Write test items to measure the behavior stated in the behavioral objective.
3. Select or design instruction to achieve the behavioral objectives.
4. Implement instruction with learners from the intended population.
5. Evaluate learner performance.
6. Revise instruction and/or procedures based on the learners' performance.

The current state of the art, with respect to system models for the design of instruction, has drawn heavily from the early work in programmed instruction, military training, and the system concepts developed by the military for the design and implementation of new weapon systems. Morgan and Morgan (1968) considered the development of programmed instruction as an educational effort that was analogous to the application of the systems approach. Dick (1969) considered that terms such as "systems analysis," "a systems approach," and "educational technology," when used to refer to the process involved in the preparation of instructional materials, are not intended to describe the learning process.

Dick's (1969) model for the systems approach has evolved as a set of procedures which can be followed in the preparation of instructional materials. Briggs, Campeau, Gagné, and May (1966) described a recommended procedure for choosing instructional media for each stated behavioral objective. Briggs (1970) incorporated the procedures for selecting media and procedures for sequencing instruction (Briggs, 1968) into a general strategy for the design of instruction. A comparison between Dick's (1969) and Briggs' (1970) models for design of instruction reveals that they contain essentially the same processes but are represented in different degrees of elaboration. Similar models for design of instruction have been discussed by Bunderson and Butts (1969), Childs (1968), Corey (1967), Cyrs and Lowenthal (1970), Eraut (1967), Glaser (1965; 1966; 1968), Haney, Lange, and Barson (1968), Homme, Csanyi, Gonzales, and Rechs (1969), Kibler, Barker, and Miles (1970), LeBaron (1969a), Lindvall and Bolvin (1967), Tosti and Ball (1969) and Tyler (1949). The work of Quinn (1967; 1968), Rundquist (1967), Smith (1966) and Thomas (1970) is representative of the work that has been done by or for the military training commands. Moore (1970) and Ullmer (1867; 1969) have discussed models as they apply to instruction in institutions of higher education.

Implementation of System Models

System models for design of instruction have been applied to an ever increasing variety of instructional environments. The two best known projects to apply a system model are the Program for Learning in Accordance with Needs (PLAN) (Flanagan, 1967; 1968) and Individually Prescribed Instruction (IPI) (Lindvall & Bolvin, 1967). Morgan and Morgan (1968) described the role of system models for design of instruction within the context of the ES '70 project.

Barson (1967) and Haney, et al., (1968) described the application of system models in four universities which involved eight courses each with a minimum annual enrollment of 500 students. Thornton and Brown (1968) reviewed current multi-media projects and applications of system models in higher education. Additional programs developed for in-service teacher education were reported by Deterline (1968) and Miller (1967).

Government and military projects which have involved the application of system models include: U.S. Naval Academy (Quinn, 1967, 1968; Tosti & Ball, 1969), Job Corps projects (Harmon, 1969), and instructor training for the Royal Air Force (Thomas, 1970).

Application of system models within the areas of computer-assisted instruction and computer-managed instruction is evident in the work of Bunderson and Butts (1969), Hagerty (1970), Kooi (1968) and Kooi and Coulson (1967).

The system models for design of instruction generally provide adequate descriptions of the processes involved in the model but have generally failed to provide information concerning the implementation of the model such as: (1) number of persons required to implement the model, (2) relationship between number of revision cycles and the effectiveness of the instructional materials produced, (3) costs involved in implementing the model, and (4) definition of the roles and responsibilities for each member of the implementation team. The work of D. Markle (1967) and Short, Geear, Haughey, & Tien (1968) have demonstrated that when a system model for design of instruction was applied to a training problem that the process not only produced instruction which was more effective than traditional methods but also resulted in reduced training time requirements. Reports of the work completed by Hagerty (1970), D. Markle (1967) and Short, et al., (1968) demonstrate a trend toward more complete reporting of the implementation of system models in terms of resources required, activities performed, and evaluation of the learner's performance.

The review of existing system models for design of instruction revealed that the knowledge gained from the present study would provide new and relevant knowledge concerning: (1) an analytical comparison between two existing models and PIERIM, and (2) information concerning the actual implementation of the model in terms of personnel involved, job descriptions, materials produced and cost estimates for each of the system components.

Mastery Models and Criterion-Referenced Measures

The mastery model described by Mayo (1970) was based, in part, on earlier work by Carroll (1963) and Bloom (1968a). The mastery model is characterized by describing its five component strategies:

1. Inform students about course expectations, even lesson expectations or unit expectations, so that they view learning as a cooperative rather than as a competitive enterprise.

2. Set standards of mastery in advance; use prevailing standards or set new ones and assign grades in terms of performance rather than relative ranking.

3. Use short diagnostic progress tests for each unit of instruction.

4. Prescribe additional learning for those who do not demonstrate initial mastery.

5. Attempt to provide additional time for learning for those persons who seem to need it (Mayo, 1970, p. 2).

Glaser (1963; 1967), Glaser and Cox (1968), and Popham and Husek (1969) discussed not only the similarities and differences between norm-referenced measures and criterion-referenced measures, but also the application of criterion-referenced measures to evaluation of instruction. A criterion-referenced test was operationally defined to include any measure which:

1. Assesses learner performance in relation to a predetermined standard of performance.

2. Provides information as to the level of performance attained by each learner which is independent of reference to the performance of other learners (after Glaser, 1963 and Glaser and Cox, 1968).

Criterion-referenced tests are an integral part of Bloom's (1968) and Mayo's (1970) mastery models.

Ebel (1962) discussed ten principles which should be considered when tests of educational achievement were being prepared and used. The first five principles were considered to be equally applicable to criterion-referenced measures:

1. The measurement of educational achievement is essential to effective education.

2. An educational test is no more or less than a device for facilitating, extending, and refining a teacher's observation of student achievement.

3. Every important outcome of education can be measured.

4. The most important educational achievement is command of useful knowledge.

5. Written tests are well suited to measure the student's command of useful knowledge (p. 20-22).

Based on the results reported by Bloom (1968a), the implementation of the mastery model was determined to be appropriate for use at the university level; and significant improvement, as measured by learner performance, was reported. In reference to higher education, Mitzel (1970) predicted that by the year 2000 "the major changes will be primarily characterized by individualization of instruction leading to sophisticated systems of adaptive education (p. 439)." Glaser (1965) concluded that the analysis and specification of behavioral objectives would have the greatest single impact on improving our education system. The statement of behavioral objectives is the crucial first step for both the mastery model and system models for design of instruction.

Three of Garvin's (1970) general principles can be used to determine the applicability of criterion-referenced measures to programs of study at the university level:

1. Unless at least one of the instructional objectives of a unit envisions a task that must subsequently be performed at a specified level of competence in at least some situation . . .

2. If public safety, economic responsibility, or other ethical considerations demand that certain tasks be performed only by those "qualified" for them by formal instruction . . .

3. In any instructional sequence where the content is inherently cumulative and the rigor progressively greater, CRM should be used to control entry to successive units . . . (p. 7-8).

When Garvin's (1970) principles are applied to programs of teacher education, it is clearly evident that criterion-referenced measures are applicable. The relevance of present and future programs of teacher education depends upon the ability of educators to specify both the tasks and applicable situations which must be performed at a specified level of competence. The entire set of behavioral objectives, each defined by an observable behavior, applicable situation, and standard of performance would operationally define a program of teacher education.

Evaluation

Definition

Merwin (1969) reviewed the historical development and changing concept of evaluation and concluded that "concepts of evaluation have developed in response to needs for evaluational practices . . . (p. 25)." The combination of ideas from Stake's (1967) discussion of curriculum evaluation, Scriven's (1967) discussion of formative evaluation and Wittrock's (1969) discussion of evaluation of instruction resulted in the following definition:

> Formative evaluation is the collection, processing, and interpretation of data for the purpose of describing and making judgement as to the quality and appropriateness of behavioral objectives, instructional materials, environments, and learner performance, and utilizing the results to make decisions concering the modification of the instructional system from which the data was derived.

Modification of a system based on data derived from the system (e.g., output) implies feedback. Feedback has generally been defined as any output of a system which either directly or indirectly serves as future input to the system. Within the context of a mastery model or system model for design of instruction, the role of the evaluator is to utilize the output of the system to identify possible weaknesses within the system which, if corrected, would increase the efficiency of the total system and/or proportion of learners attaining the specified standard of performance.

Feedback to the instructor provides the information required to make decisions concerning the modification of instructional materials and/or procedures (Bloom, 1968a, 1969; Cronback, 1963; Glaser, 1965; Tyler, 1949, 1951; Wittrock, 1969). Feedback to the learner has been recommended by Bloom (1968a & b, 1969), Evans (1968), Glaser (1965), Guilford (1968), and Wittrock (1969) for the purpose of allowing the learner to assess the adequacy of his performance. Specific recommendations which would assist the learner in correcting deficiencies or selecting his subsequent learning activity should be included in the feedback to the learner (Bloom, 1968a, 1969; Cook, 1951; Evans, 1968). Formative evaluation and the resultant feedback to the learner have been reported to have assisted the learner by pacing the learning and motivating the learner to expend necessary effort to complete the task (Bloom, 1968a). Bloom (1968a, 1969) insisted that when formative evaluation procedures are utilized the grading should be based on a predetermined standard of performance.

There are few specific guidelines concerning the data to be collected, techniques for analyzing the data, or decision strategies for assigning priorities to the changes which must be made to an instructional system. Recommendations are reviewed for each of the following elements of an instructional system: learner, behavioral objectives, test items, instructional materials, and environment.

<u>Learner</u>

The only assumption which must be made concerning the learner is that he is capable of learning (Gagné, 1965b). Learning is an unobservable, internal process of the learner, and learning must be inferred from changes in a learner's performance before and after interacting with an instructional system (Gagné, 1965b; Wittrock, 1969). Learning may be defined as "a change in human disposition or capability, which can be retained, and which is not simply ascribable to the process of growth (Gagné, 1965b; p. 5)."

Tyler (1949) identified two primary methods of evaluating a learner's performance as paper and pencil type tests for the evaluation of cognitive skills and the collection of actual products of the learner. After the learner's performance had been evaluated, an appropriate unit had to be selected for collecting, processing and reporting the data. Flanagan (1951) discussed the relative merits of each of the following methods of summarizing learner performance: raw score, rank, level of development, growth and profile. Criterion-referenced measures dictate that at the very minimum the learner's performance must be reported in relationship to a predetermined standard of performance (Cook, 1951; Deterline, 1967; Evans, 1968; Lindvall & Cox, 1969; Wittrock, 1969) and each component should be evaluated separately (Cook, 1951; Flanagan, 1969).

S. Markle (1967) and Wittrock (1969) expressed concern for the lack of reported data used to describe the characteristics of the intended population and/or the learners who were utilized during the formative evaluation of instructional systems. It has been recommended that alternate forms of the evaluation instrument be prepared and that the learner be allowed to take a criterion-referenced test as many times as required to achieve the standard of performance specified (Bloom, 1968a, 1969; Mayo, 1970). Eraut (1967) and Silberman and Carter (1965) recommended that where behavioral objectives are sequentially dependent that mastery must be attained by a learner before he is allowed to attempt subsequent behavioral objectives.

Green (1967) and Moxley (1970) concluded that variability in learner performance is attributable to the relative inefficiency of the instructional materials. Selection procedures of learners, the lack of required prerequisite behaviors by learners, and problems related to learner motivational or emotional problems were identified as other possible sources of variation in learner performance (Deterline, 1967).

Behavioral Objectives

Mager's (1962) definition of behavioral objectives was selected as an adequate definition of the term. Wittrock (1969) suggested that more complete descriptions be made of the conditions under which the learner's behavior would be evaluated.

The need and rationale for stating educational goals in terms of learner performance has been thoroughly discussed by Gagné (1965a & 1968a) and Tyler (1949; 1951; 1964). Research studies have reported direct benefits, in terms of learner performance, from simply stating the desired behavioral objectives and then emphasizing the attainment of those objectives (Mager, 1968b; Mager & McCann, 1961; McNeil, 1966; Wittrock, 1962).

Two major problems have been identified in relation to behavioral objectives: (1) How to evaluate the behavioral objectives, and (2) A rationale for establishing a standard of performance. Scriven (1967) recommended that external judges be used to evaluate the relative importance of the behavioral objectives and the congruence between the test items and the behavioral objectives. Moxley (1970) identified the receiving system as a potential judge in the evaluation of behavioral objectives. In terms of a preservice teacher education program, the public schools would be used as a judge in the evaluation of the behavioral objectives of the program.

There appears to be three alternatives for establishing standards of performance: (1) insist upon near perfect mastery (Green, 1967), (2) select an arbitrary minimum standard (Deterline, 1967), or (3) develop a rationale for setting standards of performance (Davis, 1951). An adequate standard of performance was identified as one which when achieved by a learner would successfully predict that he would answer all remaining items correctly (Davis, 1951).

Test Items

System models for design of instruction and mastery models each identify the first concern in evaluating test items, which is to establish the content validity of the item (Bloom, 1968a; Cronbach, 1963; Ebel, 1956; Husek, 1969; Popham & Husek, 1969; Tyler, 1949; Wittrock, 1969). When test items are derived directly from statements of behavioral objectives, as they are in a system model for design of instruction, the content validity of the item has been established.

After the item format and sample test situations have been agreed upon, the next step is to start the construction of a pool of homogeneous test items (Hively, 1970; Lundin, 1970; Tyler, 1967). Hively (1970) and Lundin (1970) reported procedures that they have utilized for the generation of pools of homogeneous test items for the field of mathematics.

Empirical testing of test items, using both individual and small group procedures, has been recommended by Tyler (1949). The method of scoring the performance of a learner should be made as objective as possible (Bloom, 1969; Lindvall & Cox, 1969; Tyler, 1949; Wittrock, 1969) and the basis of scoring should be made known to the learner (Wittrock, 1969). Evans (1968) recommended the use of multiple-choice type items whenever possible and contended that the ultimate operational definition of the instructional system's objectives is the posttest used to evaluate the learner's performance.

Cox and Vargas (1966), Glaser and Cox (1968), Hills (1970), Husek (1969), Moxley (1970), Popham (1970), and Popham and Husek (1969) have all expressed concern because of the lack of appropriate methods of analyzing data from criterion-referenced measures of learner performance. The suggested recommendations have been very general in nature, such as: the proportion of learners passing an item should be low on the pretest and high on the posttest (Glaser & Cox, 1968; Moxley, 1970), and a negative discriminator in an item pool should be carefully analyzed (Popham & Husek, 1969). Specific procedures for item analysis, based on the pretest-posttest design, have been discussed by Cox and

Vargas (1966) (e.g., pretest-posttest difference index) and Popham (1970) (e.g., fourfold analysis of pretest-posttest learning states).

Instructional Material

The pretest-posttest design has been widely recommended and is essential if learning is to be inferred from changes in the learner's performance before and after interacting with an instructional system (Deterline, 1967; Glaser & Cox, 1968; Lindvall & Cox, 1969; Lumsdaine, 1965; Provus, 1969; Tyler, 1949; Wittrock, 1969). The pretest-posttest design is considered a minimal design by Tyler (1949) and additional observations of the learner's performance were recommended to estimate the retention of the performance.

When the only data available to an evaluator is from a pretest-posttest design, it is exceedingly difficult to determine which element of the instructional system should be revised. Provus (1969) described a sequence of activities which were used in evaluating performance data using the behavioral objective as the basic unit of evaluation.

The results of any evaluation of instruction, utilizing the one group pretest-posttest design (Campbell & Stanley, 1963) must consider each of the eight classes of extraneous variables, which affect internal validity, as potential sources of change in learner performance which might otherwise be attributed to the instructional system. Baker (1969) reviewed the current state of curriculum evaluation methodology and concluded that in the preceding three years little empirical work had been reported. The field of curriculum evaluation remained poorly defined.

Environment

The environment of an instructional system includes the procedures and physical facilities required to accomplish the desired interface between the learner and the instructional resources. Bloom (1968a) recognized the need for more than a simple description of the environment when reporting the evaluation of instruction. The need for a clear statement of the assumptions made concerning the instruction system was first noted by Tyler (1967). Total time available to the learner, resources, sequence of instruction, and the decisions and emphasis concerning the elements of the instructional system were identified as representing the type of information which should be included in evaluation reports (Wittrock, 1969). Dick (1968) suggested that general subjective type information from learners concerning relatively small segments of instruction would be useful in formative evaluation of instructional systems.

In the past, the application of evaluation techniques and research design to the formative evaluation of an instructional system have been, for the most part, theoretical rather than practical. Recent studies by Dick (1968), Hagerty (1970), D. Markle (1967), and Short, et al., (1968) report the results of actual developmental and evaluation studies of instructional systems. The recent work of Stufflebeam (1968, 1969) and Wallace and Shavelson (1970) provide much more detailed descriptions of the logical structures of evaluation designs which are applicable to the formative evaluation of instructional systems.

Individualized Instruction

There does not exist at this time a universally accepted definition of the term "individualized instruction." Flanagan (1967, 1968) presented four methods by which instruction could be individualized. These included (1) establishment of alternative behavioral objectives, (2) placement of students into the program based on their entry behavior, (3) development of alternative methods of instruction, and (4) provision for each student to progress through the instructional program at his own rate.

Two of the better known examples of individualized instruction programs are the Duluth Program (Esbensen, 1968) and the Individually Prescribed Instruction (IPI) program at the Oakleaf School (Cooley & Glaser, 1968). The IPI program determines the course of study and the goals related with the course of study. The student is then offered a limited choice of materials and/or methods for attaining these goals. The instruction prescribed for a student in the IPI program is decided by an instructor on the basis of the student's demonstrated achievement level. Esbensen (1968) made the point that individualized instruction and independent study are not synonomous terms. The amount of independent study incorporated in an individualized instruction program depends upon the ability level of the students involved and the requirements established by the stated behavioral objectives. Both the individualized instruction programs are characterized by the inordinate amount of paper work required to manage the instructional system. Both the Duluth and the IPI programs initially involved the use of non-automated, paper and pencil type information management systems (Cooley & Glaser, 1968; Esbensen, 1968).

Instructional Packages

The transition from traditional to individualized instruction has been seen by Diamond (1968), Loughary (1968b) and Ubben (1970) as the major impetus for the development of instructional modules or packages. Diamond (1968) anticipates that within every discipline, series of self-contained instructional modules will represent the continuum of instruction. Instructional packages or systems have been developed as supplementary materials but there appears to be growing interest in the development of complete instructional systems for specific areas of study (Loughary, 1968b). Ubben (1970) identified several different names being used to identify instructional packages: contracts, IPI, Learning Activity Package (LAP), Teaching Learning Unit (TLU), and UNIPAC. The common elements of the instructional packages were identified by Ubben (1970) as:

> Each is a set of teaching-learning materials.
>
> Each package focuses on a major learnable idea, skill or attitude.
>
> Objectives are clearly stated in behavioral terms, shifting the emphasis for performance from the instructor to the learner.
>
> Each package relies heavily on the use of learning resources which can be student-operated, allowing the student to obtain information and direction without the constant attention of the teacher.
>
> Each package attempts to use a variety of media components to provide variation in instructional modes.
>
> Each package has student evaluative devices including pretests, student selftests and posttest (p. 31-32).

Educational Technology

The national conference sponsored by Designing Education for the Future: An Eight-State Project clearly documented the scope of the problems of effectively utilizing technology in education and the potential payoffs if it can be accomplished (Morphet & Jesser, 1968). In the past, the concept of educational technology has been related to hardware (i.e., slide projectors, television, computers, etc.). Recently Gagné (1968b) and Bright (1968) among others have proposed that educational technology be viewed as a process which centers on the systematic design of instruction.

Educational technology, as it relates to instruction, is defined for this study as the processes required to design instructional modules (i.e., system models for design of instruction) and the hardware required to support the implementation of the instructional modules (i.e., instructional support system). Within the context of this study, a system model for design of instruction is used to produce the instructional modules and the computer and audio tapes are two principal components of the instructional support system used to implement the instructional modules in a self-instruction environment. Previous uses of computers and audio tapes in instructional activities are reviewed in the following sections.

Computers

Silberman (1969) and Silberman and Filep (1968) included instruction, research and development, and management as three operational applications of computers to education. There are many computer-managed instruction programs that have incorporated features other than record keeping as part of the management systems. Many of the projects are still in the developmental stage and their ultimate configurations have not been finalized. Morgan (1969) has classified the following as computer-managed instruction (CMI) projects:

> Harry Silberman's work with the Southwest Regional Educational Laboratory and the Los Angeles Public Schools; Robert Glaser of the University of Pittsburgh working with the Oakleaf School in Pennsylvania; Donald Torr of Sterling Research Institute; Don Tosti of Westinghouse Learning Corporation and Alexander Schure of New York Institute of Technology all of whom are working with the U.S. Naval Academy. All of these projects are sponsored by the U.S. Office of Education. Another large project involving CMI is headed by John Flanagan under the sponsorship of the American Institute for Research and Westinghouse Corporation (p. 100.).

Morgan (1969) concluded that the similiarities of the CMI projects--(1) the design of learning interventions based on carefully stated behavioral objectives and (2) the mediation of the computer between the student, his performance on behavioral objectives and the inventory of instructional resources related to the objectives--are greater than their differences. The structure of a CMI system written in FORTRAN programming language, which has been implemented in a public school, was described by Steffenson and Read (1970).

The potential of the computer as an instructional materials data bank or computer-based instruction was discussed by Loughary (1968a). Bianchi and Burr (1970), Clayback (1970), Cross (1970), and Eisele (1970) report the operation [illegible]I systems and research conducted utilizing the instructional materials produced by the computer systems. The research studies typically report no significant difference in learner performance (Cross, 1970). The successful application of computers to education depends on the assignment of tasks which are matched to the characteristics of the computer which the computer is uniquely or best capable of accomplishing (Muller, 1968).

Audio Tapes

Wendt and Butts (1962) cited five studies which indicated no significant differences in the instructional effectiveness of tape-recorded instruction when compared to conventional lecture presentation, and one study with differences in favor of conventional lecture presentations. Popham (1961; 1962) used tape-recorded lectures augmented by brief instructor-led discussion groups in both graduate and undergraduate education courses. When the experimental group was compared with a group taught by conventional lecture and discussion methods, no significant differences in achievement were found. Meene, Hannum, Klingensmith, and Nord (1969) confirmed and extended Popham's previous findings. Tape-recorded lectures, not augmented by group discussions, were reported to be as effective as traditional lecture presentation in supplying information to college undergraduates. The study also indicated that only 5 students in the taped-lecture groups dropped the course as compared to 58 students in the conventional lecture groups. From the study, it is impossible to determine whether to attribute the lower number of dropouts in the course to the method (e.g., taped lectures) selection process (e.g., volunteers) or possibly some unidentified variable. The students' reactions to the taped lectures were described as generally favorable.

Innovations in Education

Rogers' (1962) observation that the average American school lags 25 years behind the best practice was supported by studies of educational change conducted by Mort (1964) and Mort and Cornell (1941). The early periods of educational change are characterized by activities which serve to sensitize and motivate individuals and groups to change. The early period of educational change is thought to last approximately 15 years and results in from only 3% to 4% of the school systems having accepted a new practice (Mort, 1964).

Anderson's (1967) description of the technology of instruction, Mechner's (1965) description of behavioral technology, and Kersh's (1965) description of a process for programming classroom instruction are all very similar to the system models for design of instruction which are currently being advocated. Because of the great similarity between the process of designing programmed instruction and the current system models for design of instruction, it seems proper to use an article by Skinner (1954) to mark the inception of the use of system models for design of instruction. By using 1954 as the starting point for the use of system models for the design of instruction, and applying Mort's (1964) analysis of innovation in education, it would be evident that the first phase of change (e.g., 15 years) should be ending at this time. The second phase of approximately 20 years should be marked by a rapidly accelerated rate of acceptance and application of the new practice with approximately 75% more schools having accepted the new practice. The final phase of approximately 15 years is observed to elapse before a new idea or practice is accepted by almost 100% of the schools (Mort, 1964).

By projecting the model of change presented for the system models for design of instruction, the second phase should end approximately 1990 and the third phase after the close of the twentieth century. O'Toole (1968) stated that the use of the "systems approach" and systems analysis techniques in the design and development of instructional innovations, use of technology to improve instruction and accommodate more students and requiring students to assume a greater responsibility for their education represent the three major trends of great significance for higher education.

Moore and Heald (1968) concluded that innovation and change have high and almost automatic credibility today because educators accept the equation "change = good." Although resistance to change is currently viewed as an unpopular stance, there are seven conditions under which it is considered legitimate to resist change:

1. When the proposed change, however attractive, is unalterably out of phase with exising sequences.

2. When the proposed change takes the school system past the "point of no return" (PNR) without assurance that the new conditions beyond PNR will be better than the old.

3. When the attractiveness of proposed change is a function of an attractive but dissimilar environment.

4. When the economic consequence to existing programs is out of proportion to the potential good to be derived from the proposed change.

5. When the success of a proposed change is dependent upon specialized personnel resources unavailable to the potential adopter.

6. When potential physical, psychological, or academic dangers of great magnitude cannot be tested under controlled conditions.

7. When the proposed change will preclude or prolong a better conceived and more permanent solution to the problem under consideration (p. 117-118).

Mayhew (1967), in a Southern Regional Education Board monograph, directly addressed the problem of implementing innovative changes in the instructional programs of institutions of higher education. The techniques and mechanisms for change discussed were not highly structured models for change but rather very generalized statements such as:

1. Innovation and change are not likely to come about unless the need for them is clearly perceived (p. 36).

2. Perhaps the most important element in effecting changed practice on the part of individual professors is to contrive to have them become personally involved in a movement which makes explicit to them the importance of teaching . . . (p. 29).

3. If a teacher can be associated with others in some joint undertaking he gains considerable strength from this and seems willing to depart from orthodoxy (p. 30).

4. . . . nothing succeeds like success (p. 40).

The discussion of change strategy was concluded by Mayhew (1967) listing the following six general principles related to the implementation of change in the instructional programs of institutions of higher education:

1. . . . vigorous, strong, and occasionally ruthless administrative power is necessary (p. 44).

2. . . . all human beings, including faculty members, are sufficiently venal so that it is possible to purchase interest or to purchase loyalty (p. 45).

3. . . . leadership for innovation and change can be exerted by almost anyone who begins to make the motions of a leader (p. 45).

4. . . . improvement requires time (p. 46).

5. . . . innovation is likely to be encouraged if the institution develops a sufficiently refined system of cost accounting so that actual costs of instruction, as presently performed, can be revealed (p. 46).

6. In some way or other, the officer or agency for change must build into the planning a provision for alleviating faculty anxiety and insecurity (p. 47).

Summary

The survey of the literature clearly indicated:

1. New models for preservice programs of teacher education have been designed (Engbretson, 1969).

2. Individualization was a common element of the models for preservice programs of teacher education (Monson, 1969).

3. Behavioral objectives stated for the models were comparable with present course structure in the better teacher training institutions (Silberman & Kooi, 1969).

4. Program support systems to design, construct and test instructional modules were omitted in most of the models (Silberman & Kooi, 1969).

5. System models for design of instruction have been shown to result in instructional systems which significantly improve learner performance (Hagerty, 1970; D. Markle, 1967; Short, et al., 1968).

6. Criterion-referenced measures are applicable to programs of teacher education (Garvin, 1970).

7. Evaluation techniques for use with mastery models and criterion-referenced measures need to be developed and tested under actual instructional conditions.

8. Technology could be utilized more effectively to support instructional systems (Morphet & Jesser, 1968).

CHAPTER III

SYSTEM MODELS FOR DESIGN OF INSTRUCTION

Three system models for design of instruction were analyzed and compared on the basis of activities required to implement the model. The models selected were: (1) "A General Strategy for the Design of New Multimedia Courses of Instruction," based on Briggs (1968, 1970) and Briggs, et al., (1967), (2) "Model for the System Approach to Education," based on Dick's (1969) and Hagerty's (1970) further delineation of the steps involved, and (3) the Production, Implementation, Evaluation and Revision of Instructional Modules (PIERIM) model.

Explication of the PIERIM Model

The PIERIM model for design of instruction involves four phases of systematic interaction between an instructor (e.g., subject matter expert) and an educational technologist for the purpose of designing self-instructional modules (see Figure 2). The following explication of the PIERIM model is divided into the four phases:

Phase 1--Design of Instructional Modules

Phase 2--Implementation and Evaluation of Instructional Modules in a Conventional Classroom Environment

Phase 3--Revision of Instructional Modules and Tests

Phase 4--Implementation and Evaluation of Instructional Modules in a Self-Instruction Environment.

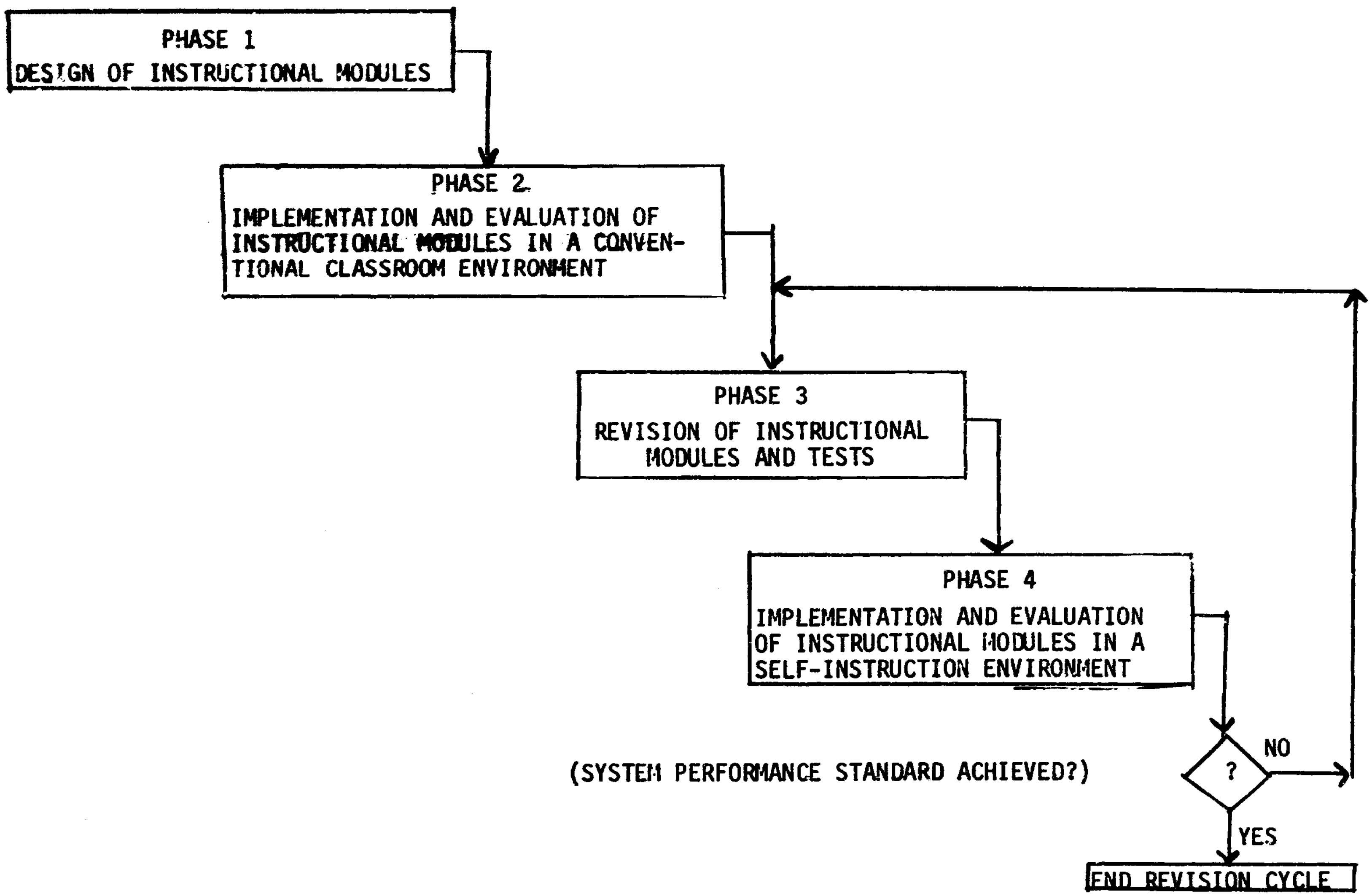


Fig.2.--A model for production, implementation, evaluation, and revision of instructional modules (PIERIM)

Phase 1--Design of Instructional Modules

The design of instructional modules is accomplished through the planned interaction between an instructor and educational technologist for the purpose of specifying: (1) content classification/identifier, (2) purpose, (3) behavioral objective, (4) test situation, and (5) resources for each of a set of observable learner behaviors that are expected to have occurred upon completion of a traditional series of lecture presentations and classroom activities. The activities required are identified for the Instructor (I) and Educational Technologist (T), as:

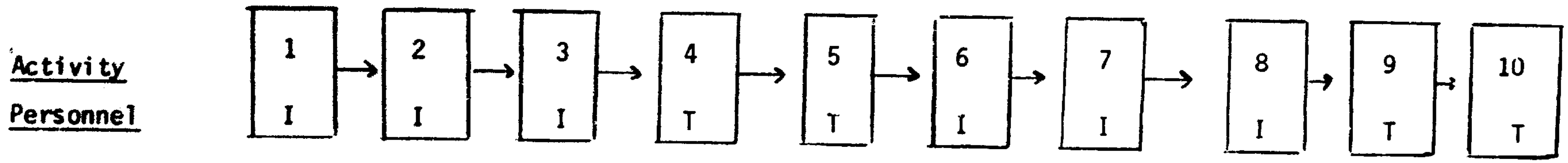
1. (I) Select the content area.
2. (I) Write a detailed outline of the content area.
3. (I) Verbally state learner competencies to be developed.
4. (T) Write behavioral objectives.
5. (T) Write sample test item for each behavioral objective.
6. (I) Verbally state the purpose for the learner achieving each behavioral objective.
7. (I) List resources for each behavioral objective.
8. (I) Categorize each behavioral objective with the content outline.
9. (T) Write instructional module for each behavioral objective.
10. (T) Write evaluation instruments.

The instructor, within the PIERIM model, has the final authority with respect to changes in instructional modules and/or test items. The educational technologist is expected to ask the instructor for the basis on which his decisions are made but the ultimate responsibility and authority within the model is assigned to the instructor. A flow chart (see Figure 3) depicts the activities associated with Phase 1--Design of Instructional Modules of the PIERIM model.

Phase 2--Implementation and Evaluation Of Instructional Modules in a Conventional Classroom Environment

The implementation of the instructional modules in a conventional classroom environment is designed to provide an opportunity for: (1) tape recording of the instructor's lectures, (2) subjective learner evaluation of the clarity and congruence among the description of purpose, behavioral objective, and test situation for each instructional module, (3) refinement of resources by the learners through the inclusion of chapter and page numbers, (4) subjective learner evaluation of resources, and (5) identification, by the learners, of additional resources related specifically to the instructional modules. The evaluation of the instructional modules represents a formative evaluation which is based on the learners' pre- and posttest performance. The activities required during Phase 2 are identified as:

11. (I) Administer pretest.
12. (T) Prepare summary of learner performance on pretest.
13. (I) Implement instructional modules in a conventional classroom environment.
14. (I) Tape record the lectures and classroom activities.
15. (I) Administer posttest.
16. (T) Prepare summary of learner performance on posttest.



Activities

1. (I) Select content area.
2. (I) Write a detailed outline of content area.
3. (I) Verbally state learner competencies to be developed.
4. (T) Write behavioral objectives.
5. (T) Write sample test item for each behavioral objective.
6. (I) Verbally state the purpose for the learner achieving each behavioral objective.
7. (I) List resources for each behavioral objective
8. (I) Categorize each behavioral objective within content outline.
9. (T) Write Instructional Modules for each behavioral objective.
10. (T) Write evaluation instruments.

Fig. 3.--Phase 1--Design of instructional modules

Phase 3--Revision of Instructional Modules

The revision of each instructional module is based on the learners' (1) subjective evaluation of the clarity and congruence among the stated: purpose, behavioral objective and test situation, (2) performance on evaluation exercises, and (3) identification of additional resources and/or refinement of existing resources. The activities required during Phase 3 are identified as:

17. (T) Revise instructional modules.

18. (T) Revise evaluation exercises.

Phase 4--Implementation and Evaluation Of Instructional Modules in a Self-Instruction Environment

This phase of the PIERIM model represents the first implementation of the instructional modules in a self-instruction environment for which they are designed. The time and instructional modules represent fixed variables in that each learner receives each instructional module and is expected to complete them within a fixed amount of time prior to the posttest.

The evaluation represents a formative evaluation of the instructional modules which is based on the learners' performance on the pre- and posttest. A portion of the instructional modules (i.e., those evaluated by multiple choice test items) are implemented in a self-instruction environment and the remainder of the instructional module (i.e., those evaluated by the instructor) are implemented in a conventional environment. For each instructional module, if the learners' performance is judged to be satisfactory (i.e., a specified proportion of the learners achieve the specified standard of performance), then the instructional module is not revised a second time. For each instructional module judged to be unsatisfactory, the cycle of revision, implementation in a self-instruction environment and evaluation is repeated until the specified proportion of the learners achieve the standard of performance. The activities required during Phase 4 are identified as:

19. (I) Administer pretest.

20. (T) Prepare summary of learner performance on pretest.

21. (I) Implement instructional modules in self-instruction environment.

22. (I) Administer posttest.

23. (T) Prepare summary of learner performance on posttest.

24. (I) Implement instructional modules, evaluated by instructor, in conventional classroom environment.

25. Repeat steps 17 through 24 until each instructional module achieves the standard set for the instructional system.

Analysis of Three System Models for Design of Instruction

Each of the system models for design of instruction (i.e., Briggs, Dick and PIERIM) are analyzed in terms of: (1) assumptions upon which the model is based, (2) personnel required to implement the model, (3) intended level of application, (4) level of analysis, and (5) activities required to be completed in the implementation of the model.

PIERIM Model

Assumptions

The PIERIM model for design of instruction is predicated upon five assumptions:

1. Performance-based teacher training programs require a variety of instructional systems, one of which could be concerned primarily with enabling learners to master relevant cognitive skills.

2. A significant portion of the cognitive skills which comprise existing preservice teacher training programs is applicable in performance-based teacher training programs.

3. The instructor is a subject matter expert.

4. The instructor is primarily a selector rather than a designer of instruction.

5. Existing system models for design of instruction are best suited for design of instruction rather than selection of instruction.

Personnel Required

The model specifically states that an instructor who is considered to be a subject matter expert and an educational technologist are required to implement the model. Each activity associated with the implementation of the model specifies which of the two persons is responsible for the accomplishment of the activity.

The educational technologist is assumed to have demonstrated his competence by either actually implementing a system model for design of instruction or having completed a course related to the application of system models for design of instruction with a grade of either A or B. Gagne (1969) identified five categories of intellectual skills which are desirable for an educational technologist: analyzing learning outcomes, techniques of measurement of outcomes, constructing empirical tests of learning outcomes, statistical competence, and communication skills. The PIERIM model operationally defines the set of activities the educational technologist must perform to implement the model. These skills can be primarily categorized under Gagné's scheme:

1. Communication skills--The educational technologist is required to communicate with the instructor, interpret the instructor's verbal description of the objectives of the course and translate the course objectives into a set of instructional modules.

2. Techniques of measurement of outcomes--The educational technologist is required to design methods of evaluating the desired outcomes of the course.

3. Constructing empirical test of learning outcomes--the educational technologist is required to construct/select the actual test situations to evaluate the learning outcomes specified.

4. Statistical competence--the educational technologist is required to analyze the learner's performance and interpret the results to the instructor. Competence in parametric and non parametric statistics is desirable.

In addition to the categories of intellectual skills described, the educational technologist is required to be competent in the production, testing, and modification of computer programs written in FORTRAN IV programming language.

Level of Application

The PIERIM model is designed specifically for application to existing courses of a preservice program of teacher education. The maximum level at which the PIERIM model is designed to operate is the course level. Any course, or portion thereof, may be selected and the PIERIM model appropriately applied to the unit of instruction selected.

Level of Analysis

Instructional modules are defined as statements which contain the following information: (1) content classification/identifier, (2) purpose, (3) behavioral objective, (4) test situation, and (5) resources (after Esbensen, 1968). The instructional module is the basic unit produced through the application of the PIERIM model and the basic unit of analysis and revision.

Activities

The following activities are required to implement the PIERIM model:

1. Select the content area.
2. Write a detailed outline of the content area.
3. Verbally state learner competencies to be developed
4. Write behavioral objectives.
5. Write sample test item for each behavioral objective.
6. Verbally state the purpose for the learner achieving each behavioral objective.
7. List resources for each behavioral objective.

8. Categorize each behavioral objective within the content outline.
9. Write instructional module for each behavioral objective.
10. Write evaluation instruments.
11. Administer pretest.
12. Prepare summary of learner performance on pretest.
13. Implement instructional modules in a conventional classroom environment.
14. Tape record the lectures and classroom activities.
15. Administer posttest.
16. Prepare summary of learner performance on posttest.
17. Revise instructional modules.
18. Revise evaluation exercises.
19. Administer pretest.
20. Prepare summary of learner performance on pretest.
21. Implement instructional modules in self-instruction environment.
22. Administer posttest.
23. Prepare summary of learner performance on posttest.
24. Implement instructional modules, evaluated by instructor, in a conventional classroom environment.
25. Repeat steps 17 through 24 until each instructional module achieves the standard set for the instructional system.

A General Strategy for Design of New Multi-media Courses of Instruction

This analysis of the system model for design of instruction is based on Briggs (1968, 1970) and Briggs, et al., (1965). The model is represented in a flow diagram (see Figure 4).

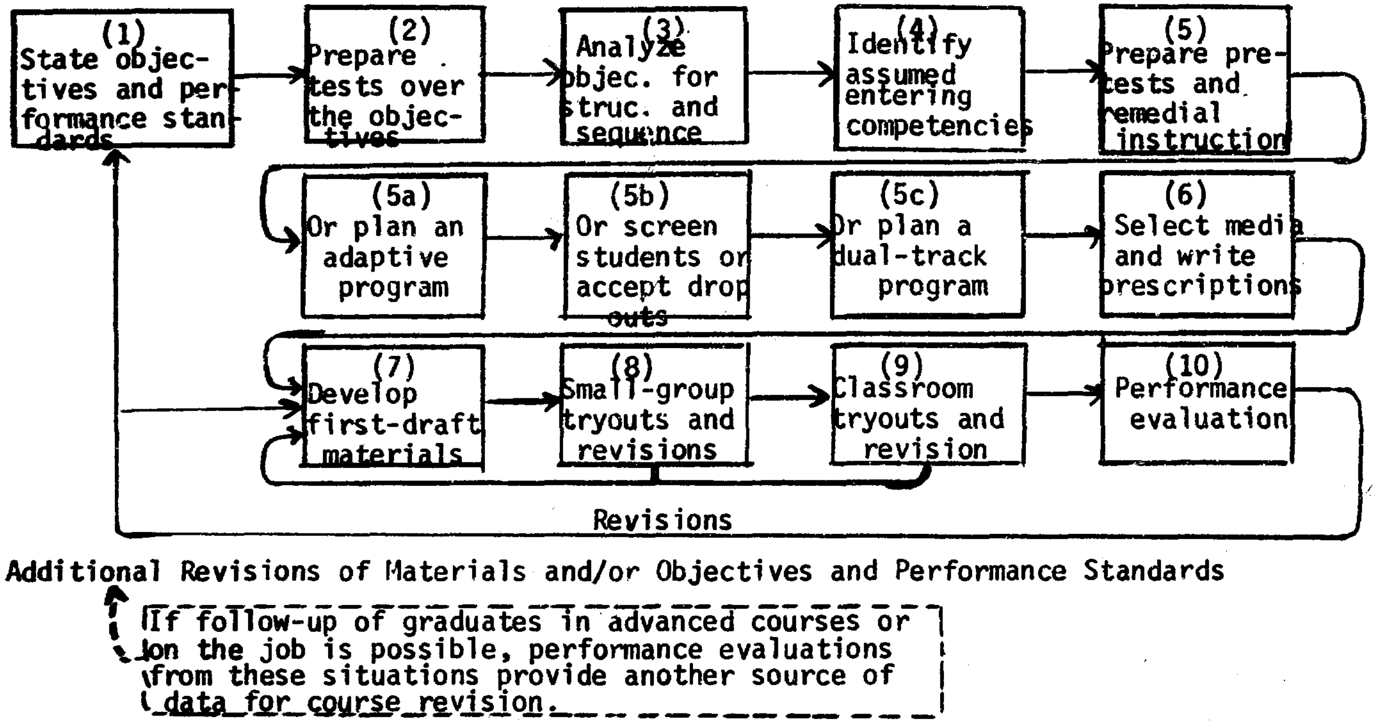


Fig. 4.--A model for the design of instruction source: L. J. Briggs <u>A Handbook of Procedures for the design of Instruction</u> (Pittsburgh, Pa.: American Institutes for Research, 1970. Copyright, AIR 1970)

Assumptions

Briggs' (1970) model is based on three assumptions:

1. Gagné's (1965) types and conditions of learning.
2. Predesigned instruction is better than instruction produced by selecting from existing resources.
3. Education and industry need to establish a new relationship for the design and production of instructional materials.

Personnel Required

No particular specialist is identified with each of the activities required to implement the model. Individuals have implemented the model for limited segments of instruction. These individuals have been enrolled in a course in instructional design taught by Dr. Briggs at the Florida State University. It may be assumed that a team of experts would generally be required to implement the model on a large scale.

Level of Application

The model is specifically intended for the design of new multimedia courses. Maximum reliance on self-instructional materials and media is encouraged but the model provides for either individualized or group instruction. A special form of the model was used as the bid specifications for the Naval Academy project. The Naval Academy project involves the design and implementation of university level courses in an individualized instruction environment.

Level of Analysis

Behavioral objectives are analyzed into subordinate competencies and the behavioral objective and subordinate competencies are sequenced according to Gagné's (1965) types of learning. The media prescriptions are written for each subordinate competency.

Activities

1. State objectives and performance standards.
2. Write test items for each behavioral objective.
3. Analyze behavioral objectives for structure and sequence.
4. Identify assumed entering competencies.
5. Prepare pretests and remedial instruction.
6. Select media and write prescriptions.
7. Produce instructional materials in the media chosen.
8. Conduct individual or small group field tests of instructional materials, and revise instructional materials on the basis of learner performance.
9. Implement the course.
10. Evaluate learner performance and revise course on the basis of learner performance.

Model for the Systems Approach to Education

The analysis of the system model for design of instruction is based on Dick's (1969) and Hagerty's (1970) further delineation of the steps involved in the model. The model is represented in a flow diagram (see Figure 5).

Assumptions

There are no assumptions explicitly stated concerning the model.

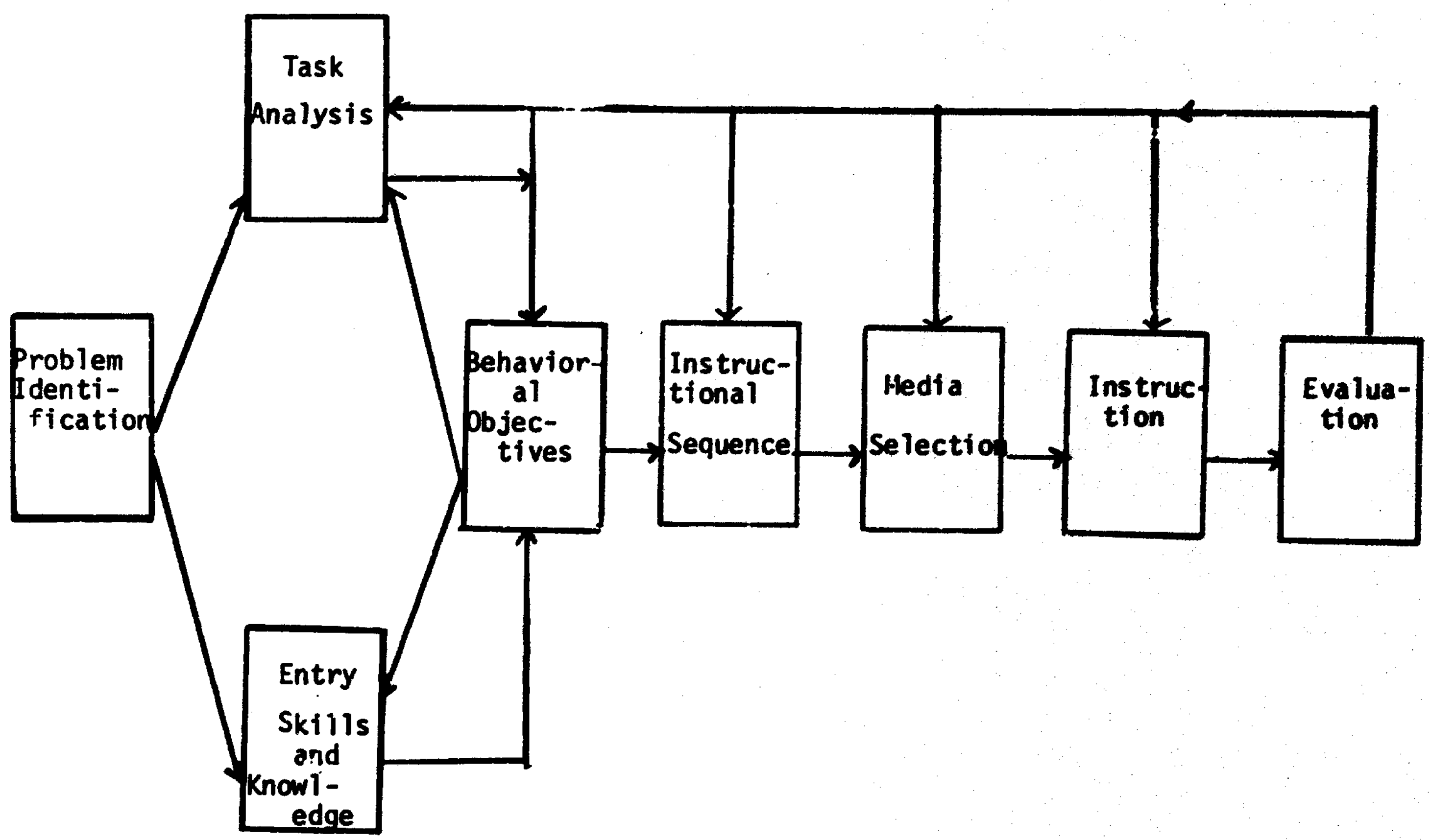


Fig. 5.--Model for the systems approach to education (after Dick, 1969)

Personnel Required

There are not any specific specialists identified with each of the activities required to implement the model. The model has been implemented by both individual learners and teams of four or five learners for the purpose of designing a limited segment of programmed instruction. The materials were developed as part of a graduate course in programmed instruction. The course has been taught at The Florida State University in conventional classroom environments and under a computer-managed instruction environment.

Level of Application

The model was originally designed to be implemented in connection with the development of programmed instruction. Although instructional materials at the level of a course or less have been developed through the implementation of the model, there is not a theoretical limit to the magnitude of the educational problem to which the model could be applied.

Level of Analysis

Terminal performance tasks are analyzed into subordinate competencies. Behavioral objectives are derived from the subordinate competencies and then the behavioral objectives are sequenced on the basis of a hierarchially derived sequence.

Activities

1. Identify the problem or content area.
2. Analyze the structure of the problem.

3. List entering skills and knowledge assumed as prerequisites.

4 Write behavioral objectives and test items for each behavioral objective.

5. Sequence the behavioral objectives.

6. Select media for behavioral objectives and produce the instructional materials.

7. Implement the instructional materials.

8. Evaluate learner performance.

9. Revise instructional materials and any preceding steps on the basis of learner performance.

Comparison of the System Models for Design of Instruction

Origin of the Models

Each of the three models evolved from distinct areas of concern: Briggs' model from problems related to the pre-design of materials specifically for objectives, Dick's model from problems related to the design of programmed instruction, and PIERIM model from the identified lack of instructional materials to support an individualized preservice teacher training program. Briggs' model was determined to be oriented exclusively to an analysis of learner behaviors while Dick's model and the PIERIM model consider learner behavior within the constraints of the content area selected.

Assumptions

Briggs' model and the PIERIM model are both based on specific assumptions. Each model makes assumptions which serve as a rationale for the development of the model. The PIERIM model also makes specific assumptions concerning the role and academic qualifications of the instructor. Briggs' model is the only model which makes any assumptions related to learning (i.e., Gagne's types and conditions of learning). The types and conditions of learning are then used as an integral part of Briggs' model. Briggs' and Dick's models are primarily concerned with design of new instructional materials and the PIERIM model is explicitly a selection model for design of instruction.

Personnel Required

Both Briggs' and Dick's models have been implemented by individuals and teams of experts. The competencies required to successfully implement either model must be derived from the author's description of the activities required to implement his model. The PIERIM model is the only one of the three models reviewed that is designed as an interactive model with each activity assigned to either the instructor or the educational technologist.

Level of Application

Each of the models is intended for application at the course level and could be applied to any subportion of a course. Briggs' and Dick's models could theoretically be applied to the design of instructional systems at any level of organization and Dick's model has been demonstrated to be applicable to educational problems other than design of instruction. The PIERIM model is intended for application only where existing courses are to be transformed into instructional modules which could be utilized in a self-instructional environment.

Level of Analysis

The most detailed analysis of learner competencies is explicitly required by the Briggs model which requires media prescriptions at the instructional event level for each subordinate competency of behavioral objectives. Dick's model requires the analysis of subordinate competencies for the stated behavioral objectives but media selection is not explicitly required at each of the subordinate competencies level of analysis. The PIERIM model does not require the analysis of behavioral objectives into subordinate competencies. The behavioral objective is the smallest unit of analysis and existing materials are then selected which will hopefully enable the learner to achieve the stated level of competency.

Activities

Each of the three models defines the instructional problem by different methods. Briggs' model assumes the existence of higher order educational goals which are then analyzed in terms of learner competencies required to achieve a higher order educational goal. Dick's model explicitly requires the statement of the problem, primarily in terms of the content to be developed or preferably in terms of desired terminal performances. The PIERIM model explicitly requires the instructor to specify the content to which the model will be applied.

Each of the models requires the statement of behavioral objectives in terms of observable learner behaviors, and test items written directly from the stated behavioral objectives.

The inclusion and/or placement of the task analysis differs for each of the models. Briggs' model starts with the statement of behavioral objectives for more general needs and then analyzes the behavioral objectives into their subordinate competencies. Dick's model, on the other hand, starts with a statement of the problem in terms of desired terminal performance and the task analysis describes the content in terms of learner competencies required to master the specified performances. The learner competencies are then stated in terms of behavioral objectives. The PIERIM model does not include a task analysis of either the content or learner behaviors. A detailed content outline is substituted for the task analysis.

Briggs' and Dick's models each require the specification of the entering learner competencies assumed as a prerequisite for the course which would be developed utilizing their models. Briggs' model provides for the development of tests and instructional materials for the prerequisite behaviors. When learners do not possess the assumed competencies, Briggs' model identifies the alternative courses of action which are available to the instructional designer. The PIERIM model does not require the specification of the assumed prerequisite learner competencies that are associated with the instructional materials that are developed.

Behavioral objectives in the Briggs model are sequenced primarily on the basis of larger needs analysis or organization of the course into several levels of objectives followed by an analysis of each behavioral objective as to the type of learning (Gagné, 1965) represented by the stated behavioral objectives. A logical analysis of the content sequence is considered an alternative, but less desirable, basis on which to sequence behavioral objectives in both Briggs' and Dick's models. The behavioral objectives are subjectively sequenced by the instructor, within the constraints of the stated content outline, for the PIERIM model.

Briggs' model represents the most extensive treatment of media selection of any of the system models for design of instruction reviewed. Media prescriptions are written separately for each useful event of the subordinate competencies. The ultimate media selection attempts to maximize the general and specific conditions of learning required to achieve a specified set of learner competencies with a minimum amount of media changes. Media selection within Dick's model is generally accomplished at the behavioral objective level. The PIERIM model selects, from all existing media, instructional materials which will hopefully enable a learner to achieve a specified behavioral objective. The primary media considered are printed materials and audio tapes.

The ability to produce the instructional materials, in the media specified by the model are implicit assumptions of both Briggs' and Dick's models. Most of the applications of Dick's model, in connection with graduate courses at The Florida State University, have resulted in the production of printed programmed instruction. Implementation of Briggs' model, by graduate students, has resulted in the production of instructional materials in the media prescribed by the media prescriptions. The PIERIM model requires the production of instructional materials in only two media: printed materials and audio tapes. An instructional module is printed for each stated behavioral objective. The Instructional Support System (ISS) was developed specifically to produce the printed materials required to implement the PIERIM model.

The first formative evaluation of instructional materials is accomplished by: individual or small group field tests, in Briggs' model; implementation of instructional modules in a conventional classroom environment, in the PIERIM model; and small group field tests of the entire unit, in Dick's model. The instructional materials and/or any preceding steps are revised on the basis of learner performance.

Each of the models subsequently implements the total course, under the actual conditions in which the course is designed to operate. The implementation-evaluation-revision cycle continues until the desired level of learner performance is achieved by each element of the course, and the course *in toto*. A cost/time decision can also be made to stop the process at a predefined level.

The major activities of the three models for design of instruction, Briggs, Dick, and PIERIM, are compared (see Table 1) for the purpose of identifying potential weaknesses in the instructional modules produced as a result of implementing the PIERIM model.

Implications for the PIERIM MODEL

The comparison of Briggs' and Dick's models for design of instruction with the PIERIM model identified each of the following as potential weaknesses in the instructional modules produced as a result of implementing the PIERIM model:

TABLE 1.--Comparison of three system models for design of instruction

BRIGGS	DICK	PIERIM
	1. State the Problem	1. Select the Content Area
	2. Analyze the Structure of the Problem (i.e., Task Analysis of Content)	2. Write a Detailed Outline of the Content Area
(See Step 4)	3. List Entering Skills and knowledge Assumed as Prerequisites	
1. State Objectives and Performance Standards	4. Write Behavioral Objectives	3. Verbally State Learner Competencies to be Developed
	4a Write Test Items for each Behavioral Objective	4. Write Behavioral Objectives
2. Write Test Items for each Behavioral Objective	(See Step 4a)	5. Write Sample Test Items for each Behavioral Objective
		6. Verbally State the Purpose of the Learner Achieving each Behavioral Objective
		7. List Resources for each Behavioral Objective
3. Analyze Behavioral Objectives for Structure and Sequence	(See Steps 2 & 5)	8. Categorize each Behavioral Objective within the Content Outline

TABLE 1.--Continued

BRIGGS	DICK	PIERIM
4. Identify Assumed Enter-Competencies	(See Step 3)	
(See Step 3)	5. Sequence the Behavioral Objectives	
5. Prepare Pretests and Remedial Instruction		
6. Select and Write Media Prescriptions	6. Select Media for Behavioral Objectives	
	6a Produce Instructional Materials	
7. Produce Instructional Materials in the Media Chosen	(See Step 6a)	9. Write Instructional Module for each Behavioral Objective
(See Step 2)	(See Step 4a)	10. Write Evaluation Instruments
8. Conduct Individual or Small Group Field Test of the Instructional Materials		11. Administer Pretest
		12. Prepare Summary of Learner Performance on Pretest
8a Revise Instructional Materials on the Basis of Learner Performance		13. Implement Instructional Modules in a Conventional Classroom Environment

TABLE 1.--Continued

BRIGGS	DICK	PIERIM
		14. Tape Record Class Lectures
		15. Administer Posttest
		16. Prepare Summary of Learner Performance on Posttest
		17. Revise Instructional Modules
		18. Revise Evaluation Exercises
9. Implement the Course	7. Implement the Instructional Materials	19. Administer Pretest
		20. Prepare Summary of Learner Performance on Pretest
		21. Implement Instructional Modules in a Self-Instruction Environment
		22. Administer Posttest
		23. Prepare Summary of Learner Performance on Posttest
		24. Implement Instructional Modules, Evaluated by Instructor in a Conventional Classroom Environment

TABLE 1.--Continued

BRIGGS	DICK	PIERIM
10. Evaluate Learner Performance	8. Evaluate Learner Performance	(See Step 22)
10a Revise Course on the Basis of Learner Performance		
(See Step 10a)	9. Revise Instructional Materials and any Preceding Steps on the Basis of Learner Performance	25. Repeat steps 17 through 24 until each Instructional Module Achieves the Standard Set for the Instructional System

1. The relevance of the instructional module cannot exceed the relevance of the subject matter content when compared to a specific teacher behavior. System models for design of instruction (Briggs, (1970; Dick, 1969) design instruction for a set of specific learner competencies as contrasted to the PIERIM model which converts existing course content into a set of instructional modules. The content validity of instruction designed for a specific teacher competency using either Briggs' (1970) or Dick's (1969) model is established by the procedures used to design the instruction. Procedures, external to the PIERIM model, must be utilized to establish the content validity of the instructional modules and/or the subject matter content from which the modules were derived.

2. The instructional modules, in toto, might be insufficient to achieve a specified learner behavior. Briggs' (1970) and Dick's (1969) models provide for the analysis of terminal learner behaviors into a set of subordinate competencies and revision of instructional materials and/or any of the set of activities prescribed by the model until the prescribed standard of performance is achieved. The PIERIM model could produce a set of instructional modules, each of which was capable of producing the desired change in learner behavior, but the total set of instructional modules could still fail to achieve a specific learner behavior because of the existence of an unidentified learner competency not contained in the subject matter content from which the modules were derived.

3. The instructional resources that are matched with an instructional module could be inadequate to achieve the desired learner

behavior. Briggs' (1970) and Dick's (1969) models design instruction for a specific learner behavior and the design-implementation-evaluation-revision cycle continues until the desired standard of performance is achieved. The PIERIM model is totally dependent upon existing resources. The maximum effectiveness of an instructional module produced through the implementation of the PIERIM model is determined by the combined effectiveness of existing resources. The actual level of effectiveness is limited by the instructor's and educational technologist's knowledge of the resources and/or sources of resources and their ability to make the resources available to the learners.

The relevance of the instructional modules is considered the most serious of the three potential weaknesses. Expert opinion was chosen as the method to be used in determining the relevance of the instructional modules developed in the present study for a preservice teacher training program. Faculty members from the departments of Elementary Education and Educational Research at The Florida State University were chosen to serve as the experts.

The deficiencies of the entire set of instructional modules, which are implemented in the self instruction environment, will be identified by the necessity for the instructor to present instruction related to behavioral objectives which have not previously been identified. Additional behavioral objectives which the learners are required to master prior to achieving mastery on the set of instructional modules which have been implemented in the conventional classroom environment will subsequently be developed into instructional modules.

The inadequacies of existing resources will be indicated by the learners' performance on the posttest being approximately equal to or less than their performance on the pretest. Additional weaknesses of the PIERIM model are expected to become apparent during the actual implementations of the model.

CHAPTER IV

IMPLEMENTATION OF THE PIERIM MODEL: PHASE 1

Introduction

The implementation of the PIERIM model, for a portion of an undergraduate elementary education course, was conducted in order to:

1. Determine the feasibility of implementing the model.
2. Refine the job descriptions for the participants in the implementation.
3. Estimate the cost of implementing the PIERIM model in terms of personnel and materials.
4. Evaluate the learners' performance when utilizing the instructional modules and tests produced using the PIERIM model.
5. Recommend the contents of training materials that could be used to develop the skills identified for the participants of the implementation.

The selection of the course and instructor, which occurred prior to the implementation of the PIERIM model, are discussed and then the implementation of each of the four phases of the model is reported separately. Each phase of the PIERIM model is reported in relationship to:

1. Activities prescribed by the PIERIM model.
2. Chronology of actual events.
3. PIERIM model compared with the actual activities.
4. Summary of learner performance (i.e., Phase 2 and Phase 4).
5. Cost analysis.

A restatement of the activities prescribed by the PIERIM model provides the framework within which the actual activities, reported in the chronology of events, are reviewed and evaluated.

The summary of learner performance for Phase 2 and Phase 4 of the PIERIM model is limited to the following descriptive statistics for the pre- and posttest: mean and standard deviation for the total test, reliability (i.e., KR-20) of the total test, and the mean and standard deviation for each instructional module. A more detailed analysis of the learners' performance is presented in Chapter VIII, Instructional Support System.

Cost estimates are based on the actual funds required to pay for personnel, on an hourly rate basis, and for resources on an actual consumption basis. An overhead rate of 18% is applied to the total cost of personnel and consumable resources. The cost factors are based on the salary and material costs applicable at The Florida State University during the Spring quarter of the 1969-1970 school year.

From the set of 25 instructional modules which were developed as part of this study, an instructional module (i.e., Reliability/Factors Affecting) was selected for the purpose of describing and documenting the activities associated with the implementation of the PIERIM model.

Selection of Course

The selection of the course in which to implement the PIERIM model was influenced by two artificial constraints:

1. The course had to be offered for two consecutive quarters.

2. The instructional materials produced would be applicable to the Florida State University Preservice Elementary Teacher Training Model.

The course selected, EED 405--Classroom Organization and Pupil Evaluation, satisfied both requirements and was a required course for elementary education majors.

Selection of Instructor

Implementation of the PIERIM model is dependent upon obtaining the cooperation of a member of the instructional staff. All staff members scheduled to teach the selected course were advised of the general nature and purpose of the PIERIM model. One of the five instructors asked for more information concerning the PIERIM model and clarification of the instructor's responsibility. The educational technologist discussed the PIERIM model and emphasized the role of the instructor and the nature of the instructional modules which would be produced as a result of implementing the model. The instructor studied the model for one week, after which he stated that he did not wish to participate in the study. The reasons given for not participating were related to the perceived lack of compatibility between the use of the instructional modules in a self-instruction environment and the instructor's style of teaching (i.e., group oriented discussion and activities) and the extensive use of the tape recorder.

A graduate assistant in the Department of Elementary Education was scheduled to assist one of the faculty members in teaching the course, Classroom Organization and Pupil Evaluation. A meeting was conducted with the faculty member, graduate assistant and educational technologist for the purpose of describing the PIERIM model in greater detail. The faculty member had given the graduate assistant primary responsibility for developing the instruction for that portion of the course related to pupil evaluation. The graduate assistant, henceforth referred to as the instructor, and the educational technologist discussed the PIERIM model and the role of the instructor within the model. Subsequently the instructor agreed to participate in the implementation of the PIERIM model. The assumption of the PIERIM model which considered the instructor to be a subject matter expert was not considered to have been violated. This conclusion is based on the formal courses, related to evaluation and measurement, that the instructor had completed.

Attaining the cooperation of an instructor is a critical activity in the implementation of the PIERIM model. Since the implementation of the PIERIM model provides instructional modules and related test items, learner performance data, and estimates of time and costs required to implement the model, this information can be used by the educational technologist in obtaining the cooperation of instructors for future implementations of the PIERIM model and to revise the activities prescribed by the model.

Phase I--Design of Instructional Modules

The design of instructional modules is accomplished through the planned interaction of an instructor and an educational technologist for the purpose of specifying content classification/identifier, purpose, behavioral objective, test situation, and resources for each of a set of observable learner behaviors that are expected to have occurred upon completion of a traditional series of lecture presentations and classroom activities. The five categories of information operationally define an instructional module. The instructor, within the PIERIM model, has the final authority with respect to changes made to the instructional modules and/or test items. The educational technologist is expected to ask the instructor for the basis on which his decisions are made but the ultimate responsibility and authority within the PIERIM model is assigned to the instructor.

Activities Prescribed by PIERIM Model

The activities prescribed by the PIERIM model for Phase 1--Design of Instructional Modules are identified for the Instructor (I) and the Educational Technologist (T) as:

1. (I) Select the content area.
2. (I) Write a detailed outline of the content area.
3. (I) Verbally state learner competencies to be developed.
4. (T) Write behavioral objectives.
5. (T) Write sample test item for each behavioral objective.
6. (I) Verbally state the purpose for the learner achieving each behavioral objective.

7. (I) List resources for each behavioral objective.

8. (I) Categorize each behavioral objective within the content outline.

9. (T) Write instructional module for each behavioral objective.

10. (T) Write evaluation instruments.

Chronology of Events

The activities related to Phase 1--Design of Instructional Modules were documented through the evolution of written materials and the use of audio tapes made for each work session. The activities are reported in their actual order of occurrence. Each activity is identified as to date, personnel involved, time estimate and a description of the activity. The time reported is the total time required to develop the entire set of 25 instructional modules.

DATE	PERSONNEL	TIME/HR.	ACTIVITY
12/12/69	T	1.0	Discuss the PIERIM model with instructor
1/09/70	I & T	.5	Discuss the PIERIM model with instructor
1/14/70	I	1.2	Outline content area
1/14/70	I & T	.4	Conduct Work Session - 1
1/15/70	I	.9	Verify scope of content area outline
1/15/70	T	1.0	Review tape of Work Session - 1 Prepare questions for next work session
1/18/70	T	2.0	Write behavioral objectives Write/select test items for behavioral objectives Write content area outline

DATE	PERSONNEL	TIME/HR.	ACTIVITY
1/19/70	I & T	.7	Conduct Work Session - 2
1/20/70	T	1.5	Review tape of Work Session - 2
1/21/70	I	1.5	Analyze contents of required text
1/22/70	I & T	.7	Conduct Work Session - 3
1/23/70	T	1.4	Review tape of Work Session - 3 Prepare questions for next work session
1/23/70	T	4.0	Select test items by content area from test item pool
1/26/70	T	3.4	Write behavioral objectives Write/select test items to match behavioral objectives
2/01/70	I	1.5	Review content outline in terms of congruence of behavioral objectives, test items, and text material
2/02/70	I & T	.5	Conduct Work Session - 4
2/02/70	T	1.0	Review tape of Work Session - 4 Prepare questions for next work session
2/03/70	T	3.0	Write behavioral objectives
2/03/70	T	5.0	Match, modify and/or write test items for behavioral objectives
2/04/70	T	3.5	Write first draft of instructional modules
2/04/70	I & T	1.4	Conduct Work Session - 5
2/04/70	T	2.0	Review tape of Work Session - 5 Prepare questions for next work session
2/04/70	I	1.5	Sequence instructional modules
2/05/70	I & T	.4	Conduct Work Session - 6
2/05/70	T	1.0	Review tape of Work Session - 6 Prepare questions for next work session

DATE	PERSONNEL	TIME/HR.	ACTIVITY
2/06/70	T	1.6	Sequence test items for pretest
2/06/70	I	.7	Review scope and sequence of instructional modules
2/07/70	T	.3	Proofread pretest
2/07/70	T	.8	Write introduction to unit
2/07/70	T	1.3	Design forms for use by the learners
2/09/70	I & T	.4	Conduct Work Session - 7
2/09/70	T	.5	Review tape of Work Session - 7
2/10/70	I & T	.5	Conduct Work Session - 8
2/10/70	T	.5	Review tape of Work Session - 8

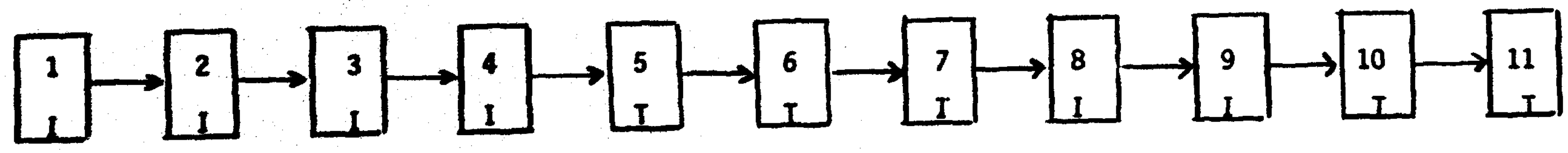
The accuracy of the chronology of events as to the date of the work sessions and the activities which occurred during each session was made possible by the practice of tape recording each of the work sessions. The tapes of each work session were reviewed by the educational technologist in preparation for the subsequent work session.

PIERIM Model Compared with the Actual Activities

The sequence of activities during Phase I -- Design of Instructional Modules was not as distinct as the flow chart (see Figure 3) would indicate. Based on the experience gained from implementation of the PIERIM model, one additional activity was identified for the instructor (i.e., evaluate behavioral objectives and test items). The responsibility for categorizing the behavioral objectives within the content outline was assigned to the educational technologist. The activities were determined to have typically occurred as shown in Figure 6.

Activity

Personnel



Activities

1. (I) Select content area.
2. (I) Write a detailed outline of content area.
3. (I) Verbally state learner competencies to be developed.
4. (I) Verbally state purpose for the learner achieving each competency.
5. (T) Write behavioral objectives.
6. (T) Categorize each behavioral objective within content outline.
7. (T) Write/Select sample test items for each behavioral objective.
8. (I) Evaluate behavioral objectives and test items.
9. (I) List resources for each behavioral objective.
10. (T) Write Instructional Modules for each behavioral objective.
11. (T) Write evaluation instruments.

Fig. 6.--Phase 1--Design of instructional modules (revised)

The evolution of the unit outline is presented (see Appendix A) in three stages: 1) the original course outline, 2) an interim unit outline, and 3) the final outline included in the learners' set of instructional materials. The first edition of the instructional module and test items which relate to Reliability/Factors Affecting (see Appendix B) is representative of the set of instructional modules and test items developed as the result of implementing Phase I--Design of Instructional Modules of the PIERIM model. The set of instructional materials which were given to each learner included:

1 Introduction

1 Outline of Evaluation Unit

16 Instructional modules which specify that multiple choice test items will be used to evaluate learner performance

9 Instructional modules which specify that the instructor will evaluate the learners' performance by either short constructed responses or problem solving exercises.

2 Tables

5 Forms for the learners' use.

The titles of the 25 instructional modules are presented in Table 2.

Old examinations and test item pools were determined to be a valuable source of multiple choice type items. Examination of sets of test items which had been classified by content area was determined to be one means by which the instructor defined the scope of the learner competencies to be developed. Approximately 75 percent of the test items developed or selected were ultimately utilized by the instructor as either sample test items or as items on the pre- and posttests. The pretest consisted of 42 multiple choice items and

TABLE 2.--Instructional modules designed during phase I and method of evaluation specified

INSTRUCTIONAL MODULE	METHOD OF EVALUATION TEST	METHOD OF EVALUATION INSTRUCTOR
Pretest/Posttest	X	
Behavioral Objectives	X	
Test Items/Behavioral Objectives		X
Test Items	X	
Percentile Ranks	X	
Percentile Ranks		X
Measures of Central Tendency	X	
Measures of Central Tendency		X
Standardized Tests/Derived Scores		X
Normal Distribution	X	
Normal Curve	X	
Standardized Tests/Derived Scores Percentile/Stanine		X
Frequency Polygon		X
Correlation Coefficient	X	
Correlation Coefficient	X	
Validity	X	
Reliability	X	
Reliability	X	
Standard Error of Measurement	X	
Regression Toward the Mean		X
Tests, Types of	X	
Standardized Tests/Norms	X	
Standardized Tests/Sources of Information	X	
Standardized Test/Interpretation		X

the posttest consisted of the same 42 test items plus 13 additional items. The additional test items were included on the posttest for the purpose of obtaining additional item statistics. The extra items were used to replace unsatisfactory items or to form a pool of test items from which alternate forms of the test could be constructed.

Cost Analysis

The activities required to produce 30 sets of the instructional modules and tests were to type and proofread stencils from handwritten copy, and reproduce and collate the materials. The educational technologist typed the stencils and then three experienced secretaries were asked to estimate the time required to type and proofread the stencils. The average of their estimates (i.e., 8 minutes per stencil) was used in determining the cost estimates. A student assistant reproduced and collated the instructional materials and the time reported (i.e., 3.5 hours) is the actual time expended.

The costs associated with the implementation of the PIERIM model are divided into two categories:

1. Design costs, which include revision of materials.
2. Production costs, which include costs related to the Instructional Support System.

Based on the actual costs associated with the implementation of Phase I--Design of Instructional Modules (see Table 3), the cost of designing one instructional module and test items was determined to be \$9.95 (i.e., \$248.75 ÷ 25). The cost of producing one complete set of the 25 instructional modules and test items was determined to be \$1.36 (i.e., \$40.85 ÷ 30).

TABLE 3.--Cost analysis for phase I--design of instructional modules

Description of cost factor	Quantity	Unit	Rate	Design cost*	Production cost**
Instructor	9.8	Hr.	$4.00	39.20	
Educational Technologist	40.3	Hr.	$4.00	161.20	
Secretary	5.5	Hr.	$3.00		16.50
Student Assistant	3.5	Hr.	$1.50		5.15
Subtotal: Personnel				$200.40	$21.65
Audio Tapes	4	Ea.	$1.29	5.16	
Stencils	41	Ea.	$ .17		6.97
Paper	3	Reem	$2.00		6.00
Xerox	105	Pg.	$ .05	5.25	
Subtotal: Consumables				$10.41	$12.97
TOTAL				$210.81	$34.62
OVERHEAD			18%	37.94	6.23
COST: Phase I-PIERIM Model				$248.75	$40.85

*Design cost for 25 Instructional Modules and Test Items
**Production Cost for 30 sets of 25 Instructional Modules and Test Items

CHAPTER V

IMPLEMENTATION OF THE PIERIM MODEL: PHASE 2

The instructional modules and tests, designed and produced during Phase 1 of the PIERIM model, were implemented in the Evaluation Unit of EED 405--Classroom Organization and Pupil Evaluation during the Winter quarter of the 1969-1970 school year. The first group of learners (i.e., Group 1) to participate in the implementation of the instructional modules and tests were elementary education majors. The 19 learners were in either their junior and senior year and enrolled in additional courses which placed demands upon their time.

The conventional classroom environment for this study is operationally defined by the following characteristics:

1. The principle method of teaching is the group lecture and discussion method.

2. The classes are scheduled to meet at a regular time and place.

3. The classes meet for a fixed length of time.

4. The instructor and a required textbook are the primary resources utilized in the instructional program.

The activities in which the learners typically engaged during one of the three weeks of the implementation of the instructional materials included:

1. Monday, the learners participated in a group seminar in which current topics of interest could be discussed by the instructor and learners.

2. Tuesday, Wednesday, and Thursday, the class met for group lecture and discussion related to the set of instructional modules.

3. Friday, a help session was provided for those learners who needed additional assistance on the instructional modules which were evaluated by the instructor.

The learners were not required to attend class during the implementation of the instructional modules and the attendance for the lecture/discussion classes was reported to average from 11 to 13 of the 19 learners and the attendance at the help sessions was much lower. The learners were required to complete the pre- and posttest for the unit of instruction.

The implementation of the instructional modules in a conventional classroom environment is designed to provide an opportunity for:

1. Tape recording of the instructor's lectures
2. Subjective learner evaluation of the clarity and congruence among the description of purpose, behavioral objective and test situation for each instructional module.
3. Refinement of resources by the learners through the inclusion of chapter and page numbers
4. Subjective learner evaluation of resources.
5. Identification by the learners of additional resources related specifically to the instructional modules.

The evaluation of the instructional modules represents a formative evaluation which is based on the learners' pre- and posttest performance.

Activities Prescribed by PIERIM Model

The activities prescribed by the PIERIM model for Phase 2--Implementation and Evaluation of Instructional Modules in a Conventional Classroom Environment are identified for the Instructor (I) and the Educational Technologist (T) as

11. (I) Administer pretest.

12. (T) Prepare summary of learner performance on pretest.

13. (I) Implement instructional modules in a conventional classroom environment.

14. (I) Tape record the lectures and classroom activites.

15. (I) Administer posttest.

16. (T) Prepare summary of learner performance on posttest.

Chronology of Events

The activities related to Phase 2--Implementation and Evaluation of Instructional Modules in a Conventional Classroom Environment were documented through the evolution of written materials and the use of audio tapes made of each work session. Each activity is identified as to date, personnel involved, time estimate and a description of the activity. The time reported is the total time required to implement the entire set of 25 instructional modules.

DATE	PERSONNEL	TIME/HR.	ACTIVITY
2/10/70	I	1.0	Administer pretest
2/10/70	T	.4	Check and submit answer sheets to the test scoring service
2/11/70	T	.5	Pick up test and item analysis
2/11/70	I & T	.5	Set up and test tape recorder for recording class sessions
2/14/70	T	1.5	Summarize learner performance on pretest by instructional module
2/15/70	T	2.7	Prepare copy of pretest performance for each learner
2/27/70	I	1.0	Administer posttest

DATE	PERSONNEL	TIME/HR.	ACTIVITY
2/27/70	T	.5	Check and submit answer sheets to test scoring service
3/02/70	T	.5	Pick up test and item analysis
3/02/70	T	1.0	Prepare summary of learner performance for posttest using ISS program EVAL

PIERIM Model Compared with the Actual Activities

The activities originally specified for Phase 2--Implementation and Evaluation of Instructional Modules in a Conventional Classroom Environment were found to occur in the sequence specified by the PIERIM model. Activity number 14 (i.e., Tape record the lectures and classroom activities) was found to be an unsatisfactory method of documenting the implementation of the instructional modules in a conventional classroom environment. The quality of the tapes which were recorded made the tapes unacceptable as resources for the revised instructional modules. An alternative method of recording the sequence and scope of the class activities, during the implementation of the instructional modules, is to have detailed notes taken of the class lectures and discussions. The educational technologist is made responsible for this revised activity. Either a regular member of the class or a student assistant could be paid for performing the activity.

The activities associated with Phase 2--Implementation and Evaluation of Instructional Modules in a Conventional Classroom Environment (Revised) are:

12. (I) Administer pretest.
13. (T) Prepare summary of learner performance on pretest.

14. (I) Implement instructional modules in a conventional classroom environment.

15. (T) Prepare detailed notes of class lectures and activities.

16. (I) Administer posttest.

17. (T) Prepare summary of learner performance on posttest.

Summary of Learner Performance

The learners' performance was measured for the set of 16 instructional modules using the same form of a 42 item multiple choice test as the pre- and posttest. The learners were told prior to taking the pretest that the same test would be used to evaluate their performance at the end of the evaluation unit. There is no precise method of determining how this information would bias the performance data. At least two learners reported that other members of the class had the answers for some of the test items prior to taking the posttest.

The reliability of the pretest (KR-20 = .60) was greater than for the posttest (KR-20 = .52). The means and standard deviations (see Table 4) are reported for each of the 16 instructional modules separately and for the total test.

Nine of the instructional modules specified that the learners' performance would be evaluated by the instructor. The instructor was either unwilling or unable to specify the criteria he used to evaluate the learners' performance on each of these instructional modules.

Cost Analysis

In determining the personnel costs for the implementation of the instructional modules and tests only time in excess of regular

TABLE 4.--Learner performance data--Phase 2

INSTRUCTIONAL MODULES	NUMBER ITEMS	MEAN		STANDARD DEVIATION	
		PRETEST	POSTTEST	PRETEST	POSTTEST
Pretest/Posttest	3	1.42	1.74	.59	.91
Behavioral Objectives	3	1.89	2.68	.97	.57
Test Items	5	2.79	3.42	1.15	1.04
Percentile Ranks	3	1.10	1.42	.79	.67
Measures of Central Tendency	3	.58	1.32	.82	.98
Normal Distribution	3	1.37	2.05	.87	.82
Normal Curve	1	1.00	1.00	.00	.00
Correlation Coefficient	1	.58	.68	.49	.46
Correlation/Scatter Diagram	1	.36	.57	.48	.49
Validity	3	1.16	2.10	.87	.55
Reliability/Factors Affecting	3	1.05	2.42	.60	.82
Reliability/Interpretation	3	1.05	1.74	.89	.85
Standard Error of Measurement	1	.58	.74	.49	.44
Types of Tests	3	2.26	2.31	.78	.73
Test Norm Intelligence Quotient	3	1.79	2.31	.83	.86
Standardized Test Information	3	2.05	2.16	1.00	.74
TOTAL TEST	42	21.05	28.68	4.22	3.65

class time is reported for the instructor. The time required for the educational technologist to design the Instructional Support System programs is considered a one time cost and is not included in the cost analysis for the PIERIM model. The costs related specifically to the development of the Instructional Support System are reported in Chapter VIII.

From an analysis of the costs associated with the implementation of Phase 2 of the PIERIM model (see Table 5) it is evident that there are few costs involved in the actual implementation of the instructional modules and tests in a conventional classroom environment. The summary report of learner performance was prepared manually for the pretest and by the ISS program EVAL for the posttest. Comparison of the cost of producing the report by the two methods reveals that the computer produced report cost 16 cents more than the manually produced report when only consumables are included in the cost. If the additional 3.2 hours of the educational technologist's time required to manually prepare the report were included in the cost, then the computer-produced report is significantly cheaper than the manually-produced report (i.e., $1.11 vs. $13.75).

TABLE 5.--Cost analysis for phase 2--Implementation and evaluation of instructional modules in a conventional classroom environment

Description of Cost Factor	Quantity	Unit	Rate	Design Cost*	Production Cost**
Instructor	.5	Hr.	$4.00	$ 2.00	
Educational Technologist	7.6	Hr.	4.00	30.40	
Subtotal: Personnel				$32.40	
Test Scoring Service	2	Ea.	.00***		
Xerox	19	Pg.	.05		.95
ISS Program EVAL	1	Run	1.11		1.11
Subtotal: Consumables					$2.06
TOTAL				$32.40	$2.06
OVERHEAD			18%	5.83	.37
COST: Phase 2-PIERIM Model				$38.23	$2.43

*Design Cost for 25 Instructional Modules and Test Items
**Production Cost for 30 sets of 25 Instructional Modules and Test Items
***Services provided by The Florida State University to the instructional staff are paid in the overhead cost.

CHAPTER VI

IMPLEMENTATION OF THE PIERIM MODEL: PHASE 3

The precise nature of the activities which comprised Phase 3--Revision of Instructional Modules and Tests was not specified by the PIERIM model. In the original set of procedures, the learner was considered to be a major contributor to the revision of the instructional modules. The revision of each instructional module is based on the learners' subjective evaluation of the clarity and congruence among the stated purpose, behavioral objective and test situation, performance on evaluation exercises, and identification of additional resources and/or refinement of existing resources.

Activities Prescribed by PIERIM Model

The activities prescribed by the PIERIM model for Phase 3--Revision of Instructional Modules and Tests are identified for the Instructor (I) and the Educational Technologist (T) as:

17. (T) Revise instructional modules.
18. (T) Revise evaluation exercises.

Chronology of Events

The activities related to Phase 3--Revision of Instructional Modules and Tests were documented through the evolution of written materials and the use of audio tapes made of each work session. Each activity is identified as to date, personnel involved, time estimate and a description of the activity. The time reported is the total time required to revise the entire set of 25 instructional modules.

DATE	PERSONNEL	TIME/HR.	ACTIVITY
2/12/70	I & T	.4	Conduct Work Session - 9 Discuss methods of summarizing learner performance and the use of additional resources.
2/12/70	T	.7	Review tape of Work Session - 9
2/12/70	T	1.0	Review tape of class lecture
2/13/70	T	1.0	Review tape of class lecture
2/17/70	I & T	.3	Conduct Work Session - 10 Request for a summary of the number of learners achieving the standard of performance for each instructional module made by the instructor. Discuss learner reaction to the summary of performance report Identify specific weaknesses of the instructional modules which had been taught.
2/19/70	T	1.5	Select additional library books related to evaluation
2/21/70	T	2.0	Write additional test items for the posttest
2/24/70	I & T	.3	Conduct Work Session - 11 Identify specific weaknesses of the instructional modules which had been taught.
2/25/70	T	1.0	Review tape of Work Session - 10 Review tape of Work Session - 11
2/26/70	I & T	.4	Conduct Work Session - 12 Identify specific weaknesses of the instructional modules which had been taught.

DATE	PERSONNEL	TIME/HR.	ACTIVITY
2/28/70	T	.5	Review tape of Work Session - 12
3/09/70	I & T	.4	Conduct Work Session - 13 Review posttest results Discuss remaining instructional modules
3/09/70	T	7.5	Listen to tapes of remaining classroom sessions. Only tapes from 4 class sessions could be interpreted.
3/10/70	T	.9	Prepare summary of learner performance on pre- and posttest for instructor.
3/17/70	T	2.5	Review and summarize learner performance by instructional module
3/18/70	I	1.8	Review summary of learner performance
3/19/70	T	.5	Review tape of Work Session - 13
3/20/70	I & T	4.5	Conduct Work Session - 14 Complete specification of revisions required for instructional modules and test items
3/21/70	T	1.5	Review tape of Work Session - 14
3/25/70	T	2.0	Select resource books from library
3/26/70	T	5.5	Match resources with instructional modules
4/01/70	I	1.0	Arrange for use of library facilities

DATE	PERSONNEL	TIME/HR.	ACTIVITY
4/02/70	I	20.0*	Prepare audio tapes for use as resources with the instructional modules
4/15/70	I & T	.8	Conduct Work Session - 15 Review computer printed copy of instructional modules and tests.

*Time is a summary of times for 5 days.

PIERIM Model Compared with the Actual Activities

The activities associated with Phase 3--Revision of Instructional Modules and Tests began immediately upon implementation of the instructional modules. The instructor was asked to respond subjectively to the relative strengths and/or weaknesses of the instructional modules immediately after the instructional module had been taught in the conventional classroom environment. The instructor made notes directly on his copy of the instructional modules, and the notes were used to suggest needed revisions to the instructional modules. The learners' pre- and posttest performance data was analyzed and the following general strategy for revision of the instructional modules and test items was identified:

(T) Identify changes which affect all of the instructional modules.

(I) Specify desired changes to instructional modules based on the implementation of the module.

(T) Identify instructional modules with large numbers of learners in an unlearned state on both the pre- and posttest.

(T) Identify test items with low proportion of learners passing the item on the posttest.

(T) Identify test items which deviate from the other test items for the instructional module either on proportion of learners passing the item or number of learners who were in an unlearned state on both the pre- and posttest.

Library books and audio tapes, which were utilized as additional resources for the instructional modules, were available for use in the university library. The educational technologist assumed the primary responsibility for identifying additional library books which were related to the evaluation unit. The card catalog was utilized to identify the library classification number associated with books in the area of educational testing and measurement. The books were reviewed by checking the set of key words used to identify the content classification of each instructional module against the index of the book. Specific pages of each resource were matched with the appropriate instructional module. The instructor deleted any resource which he felt was inappropriate, and his main reasons for rejecting resources were (1) the resource did not relate directly to the stated behavioral objective and/or (2) the terminology and methods used to develop the topic were judged inappropriate for the intended population of the learners.

The audio tapes of the instructor's lectures had originally been identified as a resource for the revised instructional modules. Either human error or equipment failure resulted in only four of the nine lectures being recorded. The quality of the tapes which were recorded was judged to be of such poor quality as to question the feasibility of retaining the recording of classroom lectures as an activity associated with the PIERIM model. Three alternative activities which occurred and resulted in the production of audio tapes used as resources were:

(I) Review class notes and additional library resources for each instructional module.

(I) Prepare summary for each instructional module.

(I) Prepare an audio tape of the summary for each instructional module.

The instructor reported that approximately 20 hours were required to prepare the set of 11 audio tapes. Each tape was from three to eight minutes in length. A transcript of the audio tape for reliability (see Appendix C) is representative of the set of tapes used as resources for the instructional modules. The bibliography for the set of revised instructional modules (see Figure 7) lists all of the resources which were related to the set of instructional modules.

The format of the instructional modules was changed and the following three changes were incorporated into each instructional module:

1. Unfamiliar terminology, such as "productive curriculum embedded evaluation exercises," was replaced with "open book written assignment to be evaluated by the instructor."

2. Correct answers for each sample test item were indicated.

3. Pages of the instructional materials were numbered consecutively.

The headings of the instructional modules were revised to include the following: content classification, purpose, behavioral objective, sample test item (if the learner's performance is evaluated by objective test items), or test situation (if the learner's performance is evaluated by the instructor), and resources.

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TAPE NUMBER 4: PERCENTILE RANKS
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TAPE NUMBER 5: MEASURES OF CENTRAL TENDENCY
PREPARED BY MR. OTTO W. ECKMAN, 1978.

TAPE NUMBER 6: NORMAL DISTRIBUTION
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TAPE NUMBER 7: CORRELATION COEFFICIENT AND SCATTER DIAGRAMS
PREPARED BY MR. OTTO W. ECKMAN, 1978.

TAPE NUMBER 8: VALIDITY
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TAPE NUMBER 9: RELIABILITY/FACTORS AFFECTING AND INTERPRETATION
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TAPE NUMBER 11: STANDARDIZED TEST INFORMATION
PREPARED BY MR. OTTO W. ECKMAN, 1978.

Fig. 7.--Bibliography for revised instruction modules

(see Table 6) include any changes, other than correction of spelling, which were made to an instructional module. Revisions for each instructional module are reported as to the subheading of the module under which the change was made. The revisions made to the test items included the following: three items were replaced, the stems of four items were revised, and seven items required changes to one or more alternatives. The number of changes required for the set of instructional modules and test items dictated that the entire production process be repeated. Rather than repeating the manual production cycle, the ISS program IMPROD and TEST were developed to produce the instructional modules and tests. These programs and the total ISS are discussed at some length in Chapter VIII.

The activities associated with Phase 3--Revision of Instructional Modules and Tests (Revised) are:

18. (T) Identify changes which affect all of the instructional Modules.
19. (I) Specify changes to be made to Instructional Modules and/or test items based on a review of learner performance data.
20. (T) Identify additional resources for the instructional Modules.
21. (T) Match resources to each individual Instructional Module.
22. (I) Review class notes and additional resources for each Instructional Module.
23. (I) Prepare a summary for each Instructional Module.
24. (I) Prepare an audio tape of the summary for each Instructional Module.
25. (T) Revise Instructional Modules.
26. (T) Revise evaluation exercises.

TABLE 6.--Revisions--instructional modules

INSTRUCTIONAL MODULE	CATEGORY CHANGED				
	1	2	3	4	5
Pretest/Posttest	X	X	X	X	2
Behavioral Objectives				X	4
Test Items					4
Percentile Ranks					3
Measures of Central Tendency					6
Normal Distribution				X	5
Normal Curve					4
Correlation Coefficient					4
Correlation/Scatter Diagram	X				2
Validity					5
Reliability/Factors Affecting	X	X		X	5
Reliability/Interpretation	X	X			7
Standard Error of Measurement					5
Types of Tests	X	X		X	4
Test Norms/Intelligence Quotient	X	X	X		4
Standardized Test Information	X			X	2
Test Items/Behavioral Objectives			X	X	3
Percentile Rank				X	2
Measures of Central Tendency			X	X	5
Z-Scores/T-Scores	X	X	X	X	3
Percentile/Stanine	X	X	X	X	2
Frequency Polygon				X	3
Scatter Diagram	X			X	3
Regression Toward the Mean				X	1
Standardized Test/Interpretation				X	0

Category 1: Content Classification
Category 2: Purpose
Category 3: Behavioral Objective
Category 4: Sample Test Item
Category 5: Resources

X indicates that changes made in the category.
Numbers in Category 5 indicate the number of resources added to the instructional module.

Cost Analysis

In determining the personnel costs for Phase 3--Revision of Instructional Modules and Tests, only time in excess of regular class time is included for the instructor. The time estimates for the educational technologist do not include any time associated with the development and testing of the ISS programs. From an analysis of the costs associated with Phase 3 of the PIERIM model (see Table 7), the average cost of revising an instructional module and the related test items was determined to be $13.59. The cost of revising the instructional modules and tests was more expensive than the cost of designing the materials during Phase 1 of the PIERIM model. The cost of producing a complete set of instructional modules and tests, utilizing the ISS programs IMPROD and TEST, was determined to be $1.65 (i.e., $49.56 ÷ 30) per set of materials as compared to the cost of $1.36 for production of the original materials manually. The original set of materials contained fewer lines of type and it is reasonable to expect that the cost of manually producing the revised materials would be greater but there is not a method to accurately project the cost estimate. The use of the computer to produce the materials has the additional advantages of:

1. Producing exactly the required number of copies.
2. Automatically sequencing and collating the materials.
3. Reducing the time between requesting copies of the materials and receiving the completed materials.
4. Simplifying the revision and modification procedures over the traditional manual method of producing the materials. The computer produced materials have one major drawback in that the paper is too large for the learners to carry in conventional notebooks.

TABLE 7.--Cost Analysis for Phase 3--Revision of Instructional Modules and Tests

Description of Cost Factor	Quantity	Unit	Rate	Design Cost*	Production Cost**
Instructor	28.9	Hr.	$4.00	$107.60	
Educational Technologist	36.2	Hr.	4.00	144.80	
Subtotal: Personnel				$252.40	
Tapes, Cassette	8	Ea.	$1.29	10.32	
Tapes, Reel	11	Ea.	1.32		14.52
Xerox	505	Pg.	.05	25.25	
ISS program ?PROD					
Computer time	66	Sec.	.042		2.77
Lines of print	20720	Ea.	.0014		29.01
ISS program TEST					
Computer time	36	Sec.	.042		1.51
Lines of print	11620	Ea.	.0014		16.27
Subtotal: Consumables				$35.57	$64.08
TOTAL				$287.97	$64.08
OVERHEAD			18%	51.83	11.53
COST: Phase 3-PIERIM Model				$339.80	$75.61

*Design Cost for 25 Instructional Modules and Test Items
**Production Cost for 30 sets of 25 Instructional Modules and Test Items

CHAPTER VII

IMPLEMENTATION OF THE PIERIM MODEL: PHASE 4

The instructional modules and tests, revised and produced during Phase 3 of the PIERIM model, were implemented in the evaluation unit of EED 405--Classroom Organization and Pupil Evaluation during the Spring quarter of the 1969-1970 school year. The second group of learners (i.e., Group 2) to participate in the implementation of the instructional modules and tests were elementary education majors. The 28 learners were in either their junior or senior year and enrolled in additional courses which placed demands upon their time.

The self instruction environment for this study is operationally defined by the following characteristics of the environment:

1. Each learner was provided with a set of the instructional modules.
2. The principal method of teaching was individual self study.
3. There were no scheduled class meetings.
4. The audio tape and text resources were the primary resources.
5. The resources were centrally located and available to the learners upon request.

The major activities for the implementation of the revised instructional modules were:

1. The learners completed the pretest and received the instructional modules for the self instruction portion of the study (see Appendix D).
2. The learners received a summary of their pretest performance (see Figure 8) and the instructor discussed the introduction to the set of instructional modulos with the learners.

EVALUATION UNIT PRETEST

266065816 = STUDENT IDENTIFICATION NUMBER

	STUDENT PERFORMANCE	STANDARD OF PERFORMANCE
PRETEST POSTTEST	1 OF 3	2 OF 3
BEHAVIORAL OBJECTIVES	2 OF 3	2 OF 3
TEST ITEMS	3 OF 5	4 OF 5
PERCENTILE RANKS	1 OF 3	2 OF 3
MEASURES OF CENTRAL TENDENCY	1 OF 3	2 OF 3
NORMAL DISTRIBUTION	1 OF 3	2 OF 3
NORMAL CURVE	0 OF 1	1 OF 1
CORRELATION COEFFICIENT	0 OF 2	1 OF 2
CORRELATION/SCATTER DIAGRAM	0 OF 1	1 OF 1
VALIDITY	0 OF 3	2 OF 3
RELIABILITY/FACTORS AFFECTING	1 OF 3	2 OF 3
RELIABILITY/INTERPRETATION	0 OF 3	2 OF 3
STANDARD ERROR OF MEASUREMENT	0 OF 1	1 OF 1
TYPES OF TESTS	3 OF 3	2 OF 3
TEST NORMS/INTELLIGENCE QUOTIENT	2 OF 3	2 OF 3
STANDARDIZED TEST INFORMATION	3 OF 3	2 OF 3

YOU ACHIEVED MASTERY ON 4 INSTRUCTIONAL MODULES

YOU EXCEED MASTERY ON 2 INSTRUCTIONAL MODULES

Fig. 8.--Sample summary of a learner's pretest performance - group 2

3. The learners interacted with the instructional modules and resources in the self-instruction environment.

4. The learners completed the posttest and received the remaining instructional modules (see Appendix E) which were implemented by the instructor in a conventional classroom environment.

5. The learners received a summary of their posttest performance (see Figure 9).

6. The instructor completed the evaluation unit utilizing group lecture and discussion methods to implement the remaining instructional modules.

The learners were expected to start a series of classroom observation and participation activities at the same time the set of instructional modules were implemented in the self-instruction environment. These activities sharply reduced the amount of time available to the learners.

Phase 4 of the PIERIM model represents the first implementation of the instructional modules in a self instruction environment for which the instructional modules are designed. The time and instructional modules represent fixed variables in that each learner received each instructional module and was expected to complete the instructional modules within a fixed amount of time between the pre- and posttest.

Because the stated purpose of the PIERIM model is to produce instructional modules for use in a self-instruction environment, the discussion of learner performance relates to the set of 16 instructional modules implemented in the self-instruction environment. The remaining 9 instructional modules used the instructor both as the primary

EVALUATION UNIT POSTTEST

PARAGSRIA = STUDENT IDENTIFICATION NUMBER

	STUDENT PERFORMANCE	STANDARD OF PERFORMANCE
PRETEST POSTTEST	2 OF 3	2 OF 3
BEHAVIORAL OBJECTIVES	3 OF 3	2 OF 3
TEST ITEMS	5 OF 5	4 OF 5
PERCENTILE RANKS	2 OF 3	2 OF 3
MEASURES OF CENTRAL TENDENCY	2 OF 3	2 OF 3
NORMAL DISTRIBUTION	2 OF 3	2 OF 3
NORMAL CURVE	1 OF 1	1 OF 1
CORRELATION COEFFICIENT	0 OF 1	1 OF 1
CORRELATION/SCATTER DIAGRAM	1 OF 1	1 OF 1
VALIDITY	2 OF 3	2 OF 3
RELIABILITY/FACTORS AFFECTING	2 OF 3	2 OF 3
RELIABILITY/INTERPRETATION	2 OF 3	2 OF 3
STANDARD ERROR OF MEASUREMENT	1 OF 1	1 OF 1
TYPES OF TESTS	2 OF 3	2 OF 3
TEST NORMS/INTELLIGENCE QUOTIENT	2 OF 3	2 OF 3
STANDARDIZED TEST INFORMATION	2 OF 3	2 OF 3

YOU ACHIEVED MASTERY ON 15 INSTRUCTIONAL MODULES

YOU EXCEED MASTERY ON 2 INSTRUCTIONAL MODULES

Fig. 9.--Sample summary of a learner's posttest performance - group 2

resource and the evaluator of the learners' performance. The instructor reported that with the exception of one learner, the learners' performance met his standard of performance for the set of 9 instructional modules.

All of the time and cost estimates are based on the design, implementation, and revision of the entire set of 25 instructional modules.

Activities Prescribed by PIERIM Model

The activities prescribed by the PIERIM model for Phase 4--Implementation and Evaluation of Instructional Modules in a Self-Instruction Environment are identified for the Instructor (I) and the Educational Technologist (T) as:

19. (I) Administer pretest.
20. (T) Prepare summary of learner performance on pretest.
21. (I) Implement instructional modules in self-instruction environment.
22. (I) Administer posttest.
23. (T) Prepare summary of learner performance on posttest.
24. (I) Implement instructional modules, evaluated by instructor, in a conventional classroom environment.
25. Repeat activities 17 through 24 until each instructional module achieves the standard set for the instructional system.

Chronology of Events

The activities related to Phase 4--Implementation and Evaluation of Instructional Modules in a Self-Instruction Environment were documented through the observation of the activities as they occurred. Each activity is identified as to date, personnel involved, time estimate and a description of the activity.

DATE	PERSONNEL	TIME/HR.	ACTIVITY
4/20/70	I	1.0	Administer pretest
4/20/70	T	.5	Deliver test to test scoring service.
4/20/70	T	1.0	Prepare summaries of learner pretest performance.
4/21/70	I	1.0	Discuss the Introduction to the set of instructional modules.
4/29/70	I	1.0	Administer posttest.
4/29/70	T	.5	Deliver test to test scoring service.
4/30/70	T	1.0	Prepare summaries of learner performance on the posttest
5/08/70	I		Evaluation Unit completed

PIERIM Model Compared with the Actual Activities

The activities originally specified for Phase 4--Implementation and Evaluation of Instructional Modules in a Self-Instruction Environment were found to occur in the sequence specified by the PIERIM model. There were no new activities identified for Phase 4.

Summary of Learner Performance

The learners' performance was measured for the set of 16 instructional modules using the same form of a 42 item multiple choice test as the pre- and posttest. The reliability of the pretest (KR-20 = .28) was lower than for the posttest (KR-20 = .71). The means and standard deviations (see Table 8) are reported for each of the 16 instructional modules separately and for the total test.

TABLE 8.--Learner Performance data--Phase 4

Instructional Module	Number Items	Mean		Standard Deviation	
		Pretest	Posttest	Pretest	Posttest
Pretest/Posttest	3	1.45	1.82	.62	.60
Behavioral Objectives	3	2.14	2.43	.99	.62
Test Items	5	2.96	3.11	.94	.86
Percentile Ranks	3	1.28	1.93	.75	.80
Measures of Central Tendency	3	.82	1.43	.71	1.02
Normal Distribution	3	.71	1.96	.84	.94
Normal Curve	1	.86	1.00	.35	.00
Correlation Coefficient	1	.43	.89	.49	.31
Correlation/Scatter Diagram	1	.25	.64	.43	.48
Validity	3	1.36	2.03	.97	.94
Reliability/Factors Affecting	3	1.57	2.28	.62	.80
Reliability/Interpretation	3	1.28	1.86	1.06	.87
Standard Error of Measurement	1	.64	.89	.48	.31
Types of Tests	3	2.32	2.64	.66	.55
Test Norms/Intelligence Quotient	3	1.46	1.75	.62	.63
Standardized Test Information	3	2.00	2.21	.71	.72
TOTAL TEST	42	21.57	28.89	3.23	4.74

Nine of the instructional modules specified that the learners' performance would be evaluated by the instructor. The instructor reported that with the exception of one learner, who did not complete any of the assignments and received the lowest posttest score, the learners satisfactorily completed the evaluation exercises specified by the instructional modules. Twenty-four of the 27 learners completed all 9 of the instructor evaluated assignments and the remaining 3 learners completed 8 of the 9 assignments.

The ISS was fully operational in support of Phase 4 of the PIERIM model. The ISS program EVAL produced a summary of the learner's performance on both the pretest and posttest (see Figures 8 and 9) which the learner received the day after the test was completed. The purpose of reporting learner performance by instructional module is to focus the learner's attention on those areas in which his performance is less than the standard which has been set for the behavioral objective. The learners indicated that the summary of their pretest performance was used to guide their preparation for the posttest. The learners did not indicate that they wanted any additional information concerning their pretest performance other than a review of the actual test items missed. The EVAL program also produced a summary report for the instructor (see Figures 10 and 11) of the proportion of the learners achieving criterion performance for each instructional module.

The ISS program STAT produces a report which summarizes the pre- and posttest performance for the total test and for each instructional module. The STAT report for the Reliability/Factors Affecting

INSTRUCTIONAL MODULES	PROPORTION ACHIEVING CRITERION PERFORMANCE
PRETEST POSTTEST	.393
BEHAVIORAL OBJECTIVES	.786
TEST ITEMS	.250
PERCENTILE RANKS	.321
MEASURES OF CENTRAL TENDENCY	.179
NORMAL DISTRIBUTION	.179
NORMAL CURVE	.857
CORRELATION COEFFICIENT	.429
CORRELATION/SCATTER DIAGRAM	.250
VALIDITY	.479
RELIABILITY/FACTORS AFFECTING	.500
RELIABILITY/INTERPRETATION	.464
STANDARD ERROR OF MEASUREMENT	.643
TYPES OF TESTS	.893
TEST NORMS/INTELLIGENCE QUOTIENT	.536
STANDARDIZED TEST INFORMATION	.750

Fig. 10.--Pretest summary report produced by EVAL program - group 2

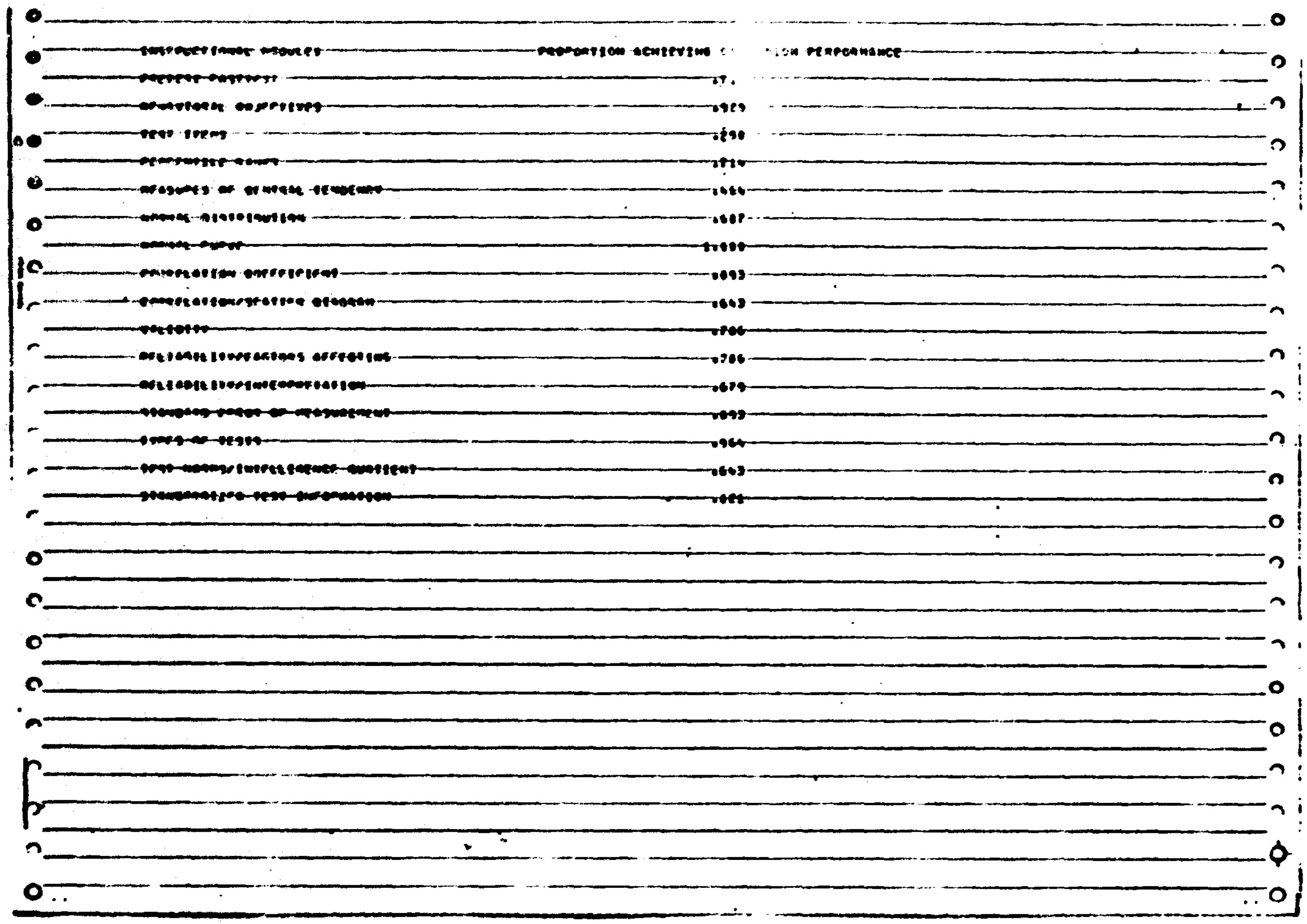

Fig. 11.--Posttest summary report produced by EVAL program - group 2

module (see Figure 12) is representative of the set of reports which was prepared for the instructor. The STAT reports are designed to be used by the instructor and educational technologist in connection with the activities related to Phase 3 of the PIERIM model (i.e., revision of instructional modules and tests). The format of the STAT report was designed to present information which had been requested by the instructor and educational technologist. The instructor reviewed the STAT reports and stated that he felt overwhelmed by the magnitude of the information contained in the reports. Additional methods of summarizing the learners' performance for the set of instructional modules were investigated and are reported in Chapter VIII--Instructional Support System.

Learner Participation

The activities requested of the learners during Phase 4 were related to the evaluation of the resources and a questionnaire concerning their attitude toward and subjective evaluation of the instructional module, tests, and procedures. The method of recording their evaluation of the resources (see Figure 13) was simplified to a single page and the learners were not asked to make a written statement concerning their decisions. The summary of the learners' responses (see Table 9) indicates that the textbook (i.e., Lindvall) and the audio tapes were consistently the most popular resources.

Analysis of the learners' responses to the questionnaire (see Appendix F) for the learners who participated in Phase 4, indicated that not all learners responded to each question and one learner

```
INSTRUCTIONAL MODULES
CONTENT CLASSIFICATION  RELIABILITY / FACTORS AFFECTING
TEST ITEMS NUMBERS  [illegible]

STUDENT PERFORMANCE
SAMPLE SIZE = [illegible]      MAXIMUM SCORE = [illegible]

                         PRETEST          POSTTEST
               MEAN =    [illegible]      [illegible]
STANDARD DEVIATION =     [illegible]      [illegible]

FREQUENCY OF PRETEST / POSTTEST SCORE CHANGES
                         POST
[illegible]

INTER ITEM CORRELATIONS
TEST ITEM        TEST ITEM      PRETEST PHI      POSTTEST PHI
[illegible]  AND [illegible]    [illegible]      [illegible]
[illegible]  AND [illegible]    [illegible]      [illegible]
[illegible]  AND [illegible]    [illegible]      [illegible]

PROPORTION CORRECT
ITEM NUMBER   PRETEST   POSTTEST   ACTUAL GAIN   POSSIBLE GAIN   RATIO: ACTUAL/POSSIBLE
[illegible]   [illegible]   [illegible]   [illegible]   [illegible]   [illegible]
[illegible]   [illegible]   [illegible]   [illegible]   [illegible]   [illegible]
[illegible]   [illegible]   [illegible]   [illegible]   [illegible]   [illegible]

NUMBER OF TEST ITEM    PASS/FAIL     PASS/PASS     FAIL/FAIL     FAIL/PASS
[illegible]           [illegible]   [illegible]   [illegible]   [illegible]
[illegible]           [illegible]   [illegible]   [illegible]   [illegible]
[illegible]           [illegible]   [illegible]   [illegible]   [illegible]

CHI SQUARE VALUES FOR THE MCNEMAR TEST FOR CHANGE
CHI SQ VALUE =  [illegible]    SIGNIFICANT AT .001 LEVEL
```

Fig. 12.--Summary report of pre- and posttest performance produced by STAT program

EVALUATION OF RESOURCES

NAME: SOCIAL SECURITY NUMBER:

DIRECTIONS: FOR EACH INSTRUCTIONAL MODULE, CIRCLE THE TWO (2) RESOURCES WHICH YOU FOUND MOST USEFUL. X-OUT ANY RESOURCES WHICH YOU FOUND CONFUSING OR THINK SHOULD BE RE-EVALUATED WHEN THE INSTRUCTIONAL MATERIALS ARE REVISED.

PRETEST/POSTTEST
GRONLUND, TAPE

BEHAVIORAL OBJECTIVES
GRONLUND, LINDEMAN, LINDVALL, NICHOLLS, TAPE

TEST ITEMS
GRONLUND, LINDEMAN, LINDVALL, PHILLIPS, TAPE

PERCENTILE RANKS
[illegible], LINDVALL, POPHAM, TAPE

MEASURES OF CENTRAL TENDENCY
GRONLUND, LINDEMAN, LINDVALL, NUNNALLY, PHILLIPS POPHAM, TAPE

NORMAL DISTRIBUTION
LINDEMAN, LINDVALL, NUNNALLY, POPHAM, TAPE

NORMAL CURVE
LINDEMAN, LINDVALL, NUNNALLY, POPHAM

CORRELATION COEFFICIENT
[illegible], LINDVALL, PHILLIPS, POPHAM, TAPE

[illegible]
LINDVALL, POPHAM, TAPE

VALIDITY
LINDEMAN, LINDVALL, NICHOLLS, NUNNALLY, PHILLIPS, TAPE

[illegible]
GRONLUND, LINDEMAN, LINDVALL, NICHOLLS, NUNNALLY, TAPE

RELIABILITY/[illegible]
[illegible], GRONLUND, LINDEMAN, LINDVALL, NICHOLLS, NUNNALLY, PHILLIPS, TAPE

STANDARD ERROR OF MEASUREMENT
[illegible], GRONLUND, LINDEMAN, LINDVALL, NUNNALLY, TAPE

TYPES OF TESTS
[illegible], LINDEMAN, LINDVALL, NICHOLLS, PHILLIPS,

TEST [illegible] QUOTIENT
[illegible], LINDEMAN, LINDVALL, NUNNALLY, PHILLIPS,

[illegible] TEST INFORMATION
LINDEMAN, LINDVALL, TAPE

PAGE NUMBER 10

Fig. 13.--Evaluation of resources form used by learners during phase 4

TABLE 9.--Learner evaluation of resources--Phase 4

Resource	Instructional Module Identifier															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Greene				0				0				0	0	0	0	
Grondlund	5	0	0		2	2	2			1	1	1				
Lindman		2	2		2	2	2			1	2	3	0	5	3	0
Lindvall		21	21	23	19	19	20	21	21	19	17	19	19	21	21	20
Micheels		0								0	0	0		0		
Nunnally					0	1	0			0	0	0			0	
Phillips			1		1			1		0		0		1	0	
Popham				1	0	0	0	0	0							
Audio Tapes	23	20	22	20	20	19		21	18	22	21	18	21			21

1. Pretest/Posttest
2. Behavioral Objectives
3. Test Items
4. Percentile Ranks
5. Measures of Central Tendency
6. Normal Distribution
7. Normal Curve
8. Correlation Coefficient
9. Correlation/Scatter Diagram
10. Validity
11. Reliability/Factors Affecting
12. Reliability/Interpretation
13. Standard Error of Measurement
14. Types of Tests
15. Test Norms/Intelligence Quotient
16. Standardized Test Information

Numbers indicate the number of learners who rated the resources as useful.

(i.e., lowest score on posttest) did not respond at all. The learners' responses to the questions indicate:

1. Nineteen of 27 learners thought that they were provided enough information to evaluate their performance on the pre- and posttest. The learners who did not think the information was adequate wanted to review the test items and answers for the tests.

2. Twenty-two of 26 learners indicated that their pretest performance was used to guide their preparation for the posttest. Four learners indicated that they did not use the information for any purpose.

3. Thirteen of 27 learners reported that they read the entire set of instructional modules in preparation for the posttest and eight learners stated that they only read specific instructional modules. Seven learners reported that they followed the same procedure of reading the instructional module, reading the text, and listening to the audio tape for each instructional module.

4. Twenty-four of 27 learners indicated that the sample test items adequately described the type test items on the posttest.

5. Twelve of 24 learners indicated that they had no difficulty in using the library books and 12 indicated that they did not use the books or the books were not available.

6. Nineteen of 25 learners reported no difficulty in using the audio tapes and 6 reported that the tapes were either not available or complained of the poor quality of the reproduction. Only one learner indicated that the tapes were generally vague and confusing.

7. The advantages of using instructional modules reported by the learners included the following: the instructional modules were specific, the learner could work at his own pace, material already

mastered could be omitted, there was more than one resource for use and a learner could repeat a unit until he was confident he had mastered the instructional module.

8. The disadvantages of using instructional modules and the self-instruction procedures were reported to include the following: the instructional modules were too narrow and detailed, the learner could not ask questions, the instructional modules lacked motivation for the learner to master the material, and application of the stated behaviors was not apparent.

9. Eighteen of 26 learners reported that they would take a course with instructional modules in preference to the same course without instructional modules.

The proportion of learners in Phase 4 who would select the course with instructional modules was only slightly higher than the proportion from Phase 2 (i.e., 12 of 18).

Comparison of Phase 2 and Phase 4

A comparison of the similarities and differences which existed during Phase 2--Implementation and Evaluation of Instructional Module in a Conventional Classroom Environment and Phase 4--Implementation and Evaluation of Instructional Modules in a Self-Instruction Environment provides a frame of reference for the analysis and interpretation of the learner performance data reported in Tables 4 and 8. The pre- and posttest means for the two groups of learners are reported in Table 10. The similarities which existed between the two implementations of the instructional modules included:

TABLE 10.--Comparison of learner performance--Phase 2 and Phase 4

Instructional Module	Number Items	Pretest Mean		Posttest Mean	
		N = 19	N = 28	N = 19	N = 28
		Group 1	Group 2	Group 1	Group 2
Pretest/Posttest	3	1.42	1.45	1.74	1.82
Behavioral Objectives	3	1.89	2.14	2.68	2.43
Test Items	5	2.79	2.96	3.42	3.11
Percentile Ranks	3	1.10	1.28	1.42	1.93
Measures of Central Tendency	3	.58	.82	1.32	1.43
Normal Distribution	3	1.37	.71	2.05	1.96
Normal Curve	1	1.00	.86	1.00	1.00
Correlation Coefficient	1	.58	.43	.68	.89
Correlation/Scatter Diagram	1	.36	.25	.57	.64
Validity	3	1.16	1.36	2.10	2.03
Reliability/Factors Affecting	3	1.05	1.57	2.42	2.28
Reliability/Interpretation	3	1.05	1.28	1.74	1.86
Standard Error of Measurement	1	.58	.64	.74	.89
Types of Tests	3	2.26	2.32	2.31	2.64
Test Norms/Intelligence Quotient	3	1.79	1.46	2.31	1.75
Standardized Test Information	3	2.05	2.00	2.16	2.21
TOTAL TEST	42	21.05	21.57	28.68	28.89

1. Course--The evaluation unit of EED 405--Classroom Organization and Pupil Evaluation was used to implement the instructional modules.

2. Instructor--The same graduate assistant instructor was given complete responsibility for the evaluation unit.

3. Population--The learners were all elementary education majors in either their junior or senior year at The Florida State University.

4. Length of Unit--The evaluation unit was allocated a total of nine one-hour class sessions.

5. Concurrent Activities--The learners were all enrolled in additional courses which placed demands on their time. The demands placed on the learners' time by activities not directly associated with the evaluation unit are assumed to be equivalent for both of the implementations of the instructional modules.

6. Attendance--The learners were not required to attend class during the implementation of the instructional modules. They were required to complete the pre- and posttest for the unit.

The significant differences between the two implementations of the instructional modules are:

1. Instructor--The instructor assisted with the entire course during Phase 2 and only with the evaluation unit during Phase 4.

2. Instructional Modules--The revision of the instructional modules resulted in substantially different instructional materials being used in the two phases of the model. The magnitude of the revisions for each instructional module is summarized (see Table 6) and depicted

in the set of materials related to the instructional module, Reliability/ Factors Affecting (see Appendix B).

3. Test Items--A set of 42 multiple choice test items was used to measure the learners' performance on the 16 instructional modules which specified multiple choice items as the method of evaluation. There were 3 test items replaced and 11 test items modified during the revision of the instructional materials.

4. Testing Procedures--The time between the pre- and posttest was reduced from 16 calendar days during Phase 2 to 8 calendar days during Phase 4.

5. Primary Resource--The instructor and text served as the primary resources during Phase 2 and the resources identified for each instructional module were the primary resources during Phase 4.

6. Availability of Additional Resources--The environment for Phase 2 was a conventional classroom. The self-instruction environment of Phase 4 was the Florida State University library. All of the resources were available in one building and additional resources could be easily located, if needed.

7. Availability of Instructor--The instructor, during Phase 2, was the primary resource and was available during the class period and by appointment. During Phase 4, the instructor was available in his office during the regular class period and by appointment.

8. Instructional Materials--The entire set of instructional modules was given to the learners at the beginning of Phase 2 and the instructional modules were divided into two sets of materials during

Phase 4 (see Appendix D and E). The set of 16 instructional modules which are evaluated by multiple choice test items was given to the learners after the pretest and the remaining instructional modules were given to the learners after the posttest.

9. Class Size--Nineteen learners participated in Phase 2 and 28 learners participated in Phase 4 of the PIERIM model.

Interpretation of Learner Performance

The learners' performance can be expected to deviate from the performance predicted by criterion-referenced measurement and mastery models of learning to the extent that the following assumptions, implicit in the procedures used to design and/or implement the instructional modules and tests, are violated:

1. Learners enter the instructional system in an unlearned state.

2. Learners, who interact with the instructional resources specified, change from an unlearned to learned state.

3. Learners possess any prerequisite competencies required to interact with the instructional resources that are identified for the instructional modules.

4. Learners have sufficient time to achieve mastery on each instructional module.

5. Test items, for each instructional module, represented a homogeneous sample of the performance described by the behavioral objective.

The learners' performance was measured for the set of 16 instructional modules using the same form of a 42 item multiple choice test as both the pre- and posttest in a One Group Pretest-Posttest Design. Revisions were made to the test during Phase 3 and this factor should be considered when comparing the performance of Group 1 (i.e., Conventional Classroom Group) and Group 2 (i.e., Self-Instruction Group). The sample size for Group 1 and Group 2 were 19 and 28 learners respectively.

Violation of Statistical Assumptions

The interpretation of learner performance data is further complicated by the use of intact classroom groups to study the effects of the instructional materials and/or procedures on the learners' performance. The use of intact classroom groups violates one of the basic underlying assumptions of inferential statistics (i.e., random sampling of learners from the population). The assumption that the underlying distribution of the trait being evaluated approximates the normal distribution is violated as the actual effectiveness of the instructional materials and/or procedures approach their theoretical limit of 100 percent effectiveness. Non-parametric statistics were selected for analysis of the learner performance data. Non-parametric statistics (i.e., phi coefficients and McNemar's Test) were selected to be reported by the ISS program STAT (see Figure 12) because there are no assumptions required concerning the underlying distribution of the performance data.

The purpose of designing and implementing the instructional modules in a self-instruction environment was for the learners to achieve at least the standard of performance specified for each of the instructional modules. Learning is inferred from gains in the proportion of learners achieving the standard of performance from pretest to posttest. It is important to remember that the research design utilized (i.e., One Group Pretest-Posttest Design) makes it impossible to separate the gains attributable to the effects of testing from the gains attributable to the instructional treatment. Utilizing the proportion of learners achieving at least the standard of performance on the pretest (see Figure 10) and posttest (see Figure 11) the gains from pretest to posttest and the ratio of the gains to potential gain are reported for each instructional module (see Table 11).

Any arbitrary standard can be selected as the performance standard for a system model for design of instruction. For purposes of illustrating the use of a standard of performance for a system model for design of instruction, 70 percent is selected as the system standard for the PIERIM model. The learners achieved the system standard of performance on four of the 16 instructional modules on the pretest and for 10 of the 16 instructional modules on the posttest (see Table 11). There would be reason to suspect that for at least the four instructional modules on which the system standard of 70 percent was achieved on the pretest that the topic had been previously taught in other education courses or the instructional objective was so obvious as not to require instruction. A comparison of the ratios of gains to potential gains requires the assumption that a gain from .800 to .900 (i.e., .10/.20 = .500) is equivalent to a gain of from .400 to .700 (i.e., 30/.60 = .500).

Role of the Learner

The learners were given three distinct roles within the implementation of the instructional modules. The learners interacted with

TABLE 11.--Changes in the Proportion of Group 2 Learners Achieving the Standard of Performance from pretest to posttest

Instructional Module	Proportions				
	Pre-Test	Post Test	Gain 1	Gain 2	Ratio Gain 1/Gain 2
Pretest/Posttest	.393	.714*	.321	.607	.528
Behavioral Objectives	.786*	.929*	.143	.214	.668
Test Items	.250	.250	.000	.750	.000
Percentile Ranks	.321	.714*	.393	.679	.579
Measures of Central Tendency	.179	.464	.285	.821	.347
Normal Distribution	.179	.607	.428	.821	.521
Normal Curve	.857*	1.000*	.143	.143	1.000
Correlation Coefficient	.429	.893*	.464	.571	.813
Correlation/Scatter Diagram	.250	.643	.390	.750	.524
Validity	.429	.786*	.357	.571	.625
Reliability/Factors Affecting	.500	.786*	.286	.500	.536
Reliability/Interpretation	.464	.679	.215	.536	.401
Standard Error of Measurement	.643	.893*	.250	.357	.700
Types of Tests	.893*	.964*	.071	.107	.663
Test Norms/Intelligence Quotient	.536	.643	.107	.464	.230
Standardized Test Information	.750*	.821*	.071	.250	.284

Gain 1 - Actual gain in the proportion of learners achieving the standard of performance from pretest to posttest.

Gain 2 - Maximum gain possible in the proportion of learners achieving the standard of performance from pretest to posttest.

* Instructional Module on which at least 70 % of the learners achieved the standard of performance specified for the behavioral objective.

the instructional modules, recommended changes in the instructional modules and/or procedures, and expressed their attitude toward the instructional modules and/or procedures. The learners' interaction with the instructional modules was not closely monitored during either Phase 2 or Phase 4 of the PIERIM model. Class attendance during either Phase 2 was optional and reported by the instructor to average from 10 to 13 of the 19 learners per day. Using self report techniques, the median number of days prior to the posttest on which the learners started their preparation for the posttest was five days for Phase 4. The learners reported that they devoted from 4 to 14 hours ($\bar{X}$ = 6.9 hours) preparing for the posttest.

The learners were asked in the introduction to the set of instructional modules, during Phase 2, to assume a professional responsibility and assist the instructor by the following:

1. Evaluate the components of each instructional module by specifically attending to the clarity of the stated behavioral objective and the congruence (i.e., agreement) between the behavioral objective and test situation.

2. State whether the resource(s) was adequate for the learner to achieve the stated behavioral objective. If multiple resources or chapters within a single resource were cited, the learner was to indicate which of the resources was the most helpful in achieving the stated behavioral objective.

3. Identify additional resources that could be used by a learner to master the stated behavioral objective.

4. Propose other evaluation topics, concepts or activities for which instructional modules should be prepared.

5. Identify any words or topics which were either confusing to learners or required more than an average amount of study for mastery.

6. Keep a diary of events in which the learner indicated any strong positive or negative feeling toward the procedures being used, materials provided, resources identified, sequence of topics, etc. Of the six proposed activities, the only activities which the learners completed and which proved useful during Phase 3 were activities one and five. There were too many activities expected of the learners and they either completely failed to complete the remaining activities or their descriptions were too general to be of any help in the revision of the instructional modules.

The activities requested of the learners during Phase 4 were subsequently reduced to an evaluation of the resources and a questionnaire concerning their attitude toward and subjective evaluation of the instructional modules and procedures. The method of evaluating the resources was simplified to a single page and the learners were not asked to make any written statements concerning their decisions.

Cost Analysis

In determining the personnel costs for the implementation of the instructional modules and tests only time in excess of regular class time is reported for the instructor. The instructor was not engaged in any activities other than the normal teaching activities during the implementation of the instructional modules. The only costs involved in the implementation of the instructional modules in a self-instruction environment are related to the production of reports of learner performance. The average cost of the summary report produced for the learner by the ISS program EVAL was six cents per report. The summary report of the pre- and posttest performance produced by the ISS program STAT was $4.00 for the report. A summary of the costs related to Phase 4 is presented in Table 12.

TABLE 12.--Cost analysis for Phase 4--Implementation and Evaluation of Instructional modules in a self-instruction environment

Description of Cost Factor	Quantity	Unit	Rate	Design Cost*	Production Cost **
Educational Technologist	3	Hr.	4.00	12.00	
Subtotal: Personnel				12.00	
Test Scoring Service	2	Ea.	.00***		
ISS Program EVAL					
Computer Time	38	Sec.	.042		1.60
Lines of Print	1266	Ea.	.0014		1.77
ISS Program STAT					
Computer Time	52	Sec.	.062		3.22
Lines of Print	528	Ea.	.0014		.78
Subtotal: Consumables				$12.00	$7.37
TOTAL				12.00	7.37
OVERHEAD			18%	2.16	1.32
COST: Phase 4--PIERIM Model				$14.16	$8.69

*Design Cost for 25 Instructional Modules and Test Items
**Production Cost for 30 sets of Instructional Modules and Test Items
***Services provided by the Florida State University to the instructional staff are paid in the overhead cost.

CHAPTER VIII

INSTRUCTIONAL SUPPORT SYSTEM

The Instructional Support System (ISS) is defined by the set of capabilities which are required to support the implementation of the PIERIM model. The implementation of the ISS in support of Phase 4 of the PIERIM model is reported in relation to: (1) test scoring services, (2) computer programs, (3) resource center, (4) methods used to establish the transferability of the instructional modules, and (5) efforts to develop a Revision Indicator for use in relation with the STAT program.

Test Scoring Service

The Division of Instructional Research and Service at The Florida State University offers a test scoring and analysis service for use by the instructional staff. The characteristics required for the evaluation of a learner's performance include methods for: (1) presenting the test items, (2) recording the learner's responses, (3) evaluating the learner's responses, (4) summarizing the learner's responses, and (5) producing a record of the learner's responses. The test scoring service provided the means of accomplishing all of the requirements with the exception of presenting the test items. The test service programs provided both total test and item analysis for the total group of learners. The response record of each learner was punched in a format which was interpretable by a computer program written in FORTRAN IV programming language.

Computer Programs

The documentation of each of the four ISS computer programs--IMPROD, TEST, EVAL, and STAT--is reported in Appendix G. The computer programs serve three functions: (1) Production of instructional modules and tests, (2) evaluation of learner performance , and (3) analysis and summary reports of learner performance data. The specific capabilities required of the ISS programs for the production of instructional modules and tests include: (1) production of any specified number of sets of instructional modules and tests, (2) sequencing of the instructional modules and test items in any order requested, and (3) revision of instructional modules and tests possible at the lowest practical level. The ISS programs, IMPROD and TEST, possess each of the capabilities specified with the line of print being used as the basic unit for revision of the instructional modules and test items. The advantages associated with the ISS computer programs are related to the transferability of the programs among universities and ease with which they can be programmed and revised. It is possible that minor modifications to the programs would be required before they would operate on computer systems other than a Control Data Corporation 6400 series computer.

The basic unit produced through the implementation of the PIERIM model was the instructional module, and learner performance was analyzed and summarized by the ISS program EVAL by instructional module.

The characteristics required for the analysis and summary of learner performance include: (1) analysis and summary of learner performance by instructional module, (2) comparison of the learner's performance with the standard of performance established for the instructional module, and (3) summary of the group's performance for each instructional module. The ISS program EVAL was designed for the analysis of a single test and is the most difficult ISS program to modify. The entire EVAL program needs to be redesigned so that the relationship between test items and instructional modules can be read into the program at the time the data is analyzed.

The analysis and summary of the pre- and posttest learner performance data by the ISS program STAT was designed on two principles: (I) all of the pre- and posttest data and computed statistics are available at the end of the program run, and (2) the instructor specifies the information and format of the summary reports of learner performance. The STAT program has a major disadvantage of requiring a minimum of 76,000 units of computer core to operate. It is possible that through the use of more sophisticated programming techniques that the STAT program could be made operational on a smaller computer system.

The cost of producing the ISS computer programs cannot be precisely determined. The educational technologist programmed, key punched, and tested each of the programs. The best estimate of the time required is 80 hours or one man month for a graduate assistant. The computer costs are estimated on the basis of 4 trial runs with program listings for each of the programs. The estimated cost of $434 includes: (1) $320 personnel--80 hours at $4 per hour, (2) $7 computer cards--7000 cards at $1 per 1000, (3) $37 computer time--300 seconds at $.042 per second and 200 seconds at $.062 per second, (4) $70 computer printing--50,000 lines of print at $.0014 per line.

The cost of producing sets of the instructional modules and tests are based on production runs of 30 sets of each of the materials. The production runs utilized binary source decks, and program listings were not produced. The cost of the summary reports of learner performance are based on the actual production costs associated with the implementation of the programs during Phase 4 of the PIERIM model. The total cost of producing the instructional modules, tests, pre- and posttest reports of learner performance for the learner, and pre- and posttest report of learner performance for the instructor was determined to be $56.93. If the 18% overhead cost is added to the computer costs, then the total cost is $67.17. The average cost of supporting the implementation of an instructional module was $2.28 or $2.69 with the overhead costs.

Resource Center

The services provided by the university library included placement of the books identified as resources for the instructional modules in the reserve room of the library, storage of the audio tapes, and facilities for listening to the tapes. The library also provided the instructor with a monthly summary of the tape usage. The usage report was for each audio tape and reported the number of times the tape was used and the time of day used. The tapes appear to have a great potential for increasing the learners' involvement with the instructional resources. The audio tapes were produced as summaries for the instructional modules and the learners generally found them to be a useful resource in preparing for the posttest (see Table 9).

Transferability of Instructional Modules

The utility of the PIERIM model and the ISS was determined to be dependent upon two major factors. First, the ability of other faculty members to agree on the relative importance of a teacher candidate's being able to demonstrate the behaviors described under the subheading PURPOSE of the instructional modules The second factor relates to the time required to modify the instructional modules for use by another faculty member. Expert opinion was used to investigate the first factor and a replication of the one week self study was used to investigate the second factor.

Ten faculty members were selected to review and evaluate the relative importance of the set of instructional modules prepared for use in the conventional classroom environment. The faculty members were selected on the basis of their having either taught the course for which the instructional modules were prepared or courses related to the area of tests and measurement offered by the Department of Educational Research. The cover letter and a sample from the set of instructional modules (see Appendix H) are representative of the materials sent to the faculty members, six from the Department of Elementary Education and four from the Department of Educational Research.

The faculty members were asked to first select those instructional modules which described behaviors they did not feel a teacher candidate should be expected to master. They were then asked to equally divide the remaining instructional modules into 4 categories: (1) most important, (2) above average in importance, (3) below average in importance, and (4) least important. Values of 4, 3, 2, and 1 were assigned to the corresponding categories and the responses were summarized for each instructional module. The responses are reported for the Department of Elementary Education and Department of Educational Research separately and for the total group (see Table 13). Two factors could bias the results: (1) two faculty members from the Department of Elementary Education did not return the materials, and (2) one of the faculty members did not have an equal number of instructional modules in each of the 4 categories. It was inferred from conversations with the faculty members who did not return the instructional modules that they perceived a conflict between their preferred teaching style and the degree of structure represented in the instructional modules.

A Spearman Rank Correlation Coefficient (r_s), corrected for tied ranks (Siegel, 1956) was calculated to determine if associations existed between the ranking of the instructional modules by the faculty members from the Department of Elementary Education and by the faculty members from the Department of Educational Research. The null hypothesis that the two rankings were unrelated was rejected (alpha = .01) for the entire set of instructional modules (r_s = .71). When the 16

TABLE 13.--Evaluation of Instructional Modules--Expert Opinion

Instructional Module	A	B	C
Pretest/Posttest	13	9	22
Behavioral Objectives	16	15	31
Test Items	16	12	28
Percentile Ranks	9	11	20
Measures of Central Tendency	11	7	18
Normal Distribution	7	8	15
Normal Curve	10	7	17
Correlation Coefficient	3	6	9
Correlation/Scatter Diagram	5	5	10
Validity	5	7	12
Reliability/Factors Affecting	8	11	19
Reliability/Interpretation	7	10	17
Standard Error of Measurement	8	10	18
Types of Test	11	6	17
Test Norms/Intelligence Quotient	15	12	27
Standardized Test Information	11	9	20
Test Items/Behavioral Objectives	15	16	31
Percentile Ranks	1	8	9
Measures of Central Tendency	7	10	17
Z-Scores/T-Scores	4	5	9
Percentile/Stanine	7	6	13
Frequency Polygon	2	4	6
Scatter Diagram	10	9	19
Regression Toward the Mean	4	6	10
Standardized Test/Interpretation	13	13	26

Numbers represent the sum of the faculty member ratings.

A - Department of Elementary Education

B - Department of Educational Research

C - Total Group

Total Set of Instructional Modules $r_s(AB) = .71$ **

Set of First 16 Instructional Modules $r_s(AB) = .58$ **

Set of Last 9 Instructional Modules $r_s(AB) = .78$ **

**Significant at .01 level

instructional modules ($r_s = .58$) evaluated by objective test items, and the 9 instructional modules ($r_s = .78$) evaluated by the instructor, were analyzed separately; the null hypothesis was likewise rejected.

The faculty members' responses to the question: Can this behavior be adequately evaluated using the stated behavioral objective and test situation? are much more difficult to interpret. The response alternatives available to the faculty member were: yes, uncertain, and no. One of the faculty members from the Department of Elementary Education responded "no" for each of the instructional modules. The summary of the faculty members' responses (see Table 14) indicates that the perceived agreement between the test situation and the behavioral objective which it is intended to evaluate is higher when the instructor evaluated the learner's performance ($\bar{X} = 5.7$ for yes category) than when objective test items were used to evaluate the learner's performance ($\bar{X} = 4.8$ for yes category).

The faculty members estimated the percentage of the evaluation unit that the set of instructional modules would represent if they were to teach the course. The Department of Elementary Education faculty members reported percentages of 0%, 50%, 70%, and 100% in contrast to a narrower range of values reported by faculty members from the Department of Educational Research of 50%, 60%, 70% and 80%.

The evidence indicates that the instructional modules produced through the implementation of the PIERIM model describe a set of learner competencies for which moderate agreement was obtained from eight faculty members concerning the relative importance of the competencies described. There was generally less agreement concerning the adequacy

TABLE 14.--Adequacy of Test Situation--Expert Opinion

Instructional Modules	Frequency of Response		
	Yes	Uncertain	No
Protest/Posttest	4	2	2
Behavioral Objectives	3	3	2
Test Items	4	2	2
Percentile Ranks	6	1	1
Measures of Central Tendency	4	2	2
Normal Distribution	4	2	2
Normal Curve	7	0	1
Correlation Coefficient	4	2	2
Correlation/Scatter Diagram	7	0	1
Validity	3	4	1
Reliability/Factors Affecting	5	1	2
Reliability/Interpretation	6	1	1
Standard Error of Measurement	3	2	3
Types of Tests	4	2	2
Test Norms/ Intelligence Quotient	5	2	1
Standardized Test Information	6	1	1
Test Items/Behavioral Objectives	6	0	2
Percentile Ranks	6	1	1
Measures of Central Tendency	7	0	1
Z-Scores/T-Scores	4	0	4
Percentile/Stanine	6	1	1
Frequency Polygon	5	2	1
Scatter Diagram	6	1	1
Regression Toward the Mean	5	2	1
Standardized Test/Interpretation	6	1	1

Numbers = frequency of responses to the question: "Can this behavior be adequately evaluated using the stated behavioral objective and test situation?"

of the objective test items for the evaluation of the learners' attainment of the stated behavioral objectives. For most of the faculty members, the set of instructional modules would represent a significant portion of the course if they were to teach the evaluation unit.

The replication of the one week self study was used to determine the time required to modify the instructional modules. The ISS was designed using programming techniques which were intended to minimize the time required to modify the instructional modules. The set of instructional modules was reviewed by an instructor of an undergraduate educational psychology course and the first 16 instructional modules were selected to be included in a one week unit, "Performance Assessment," for the course. The instructor requested that the text being used in the course be included in the resources for the instructional modules and that the text used in the original course be deleted. The activities required to modify the instructional modules were identified as:

1. Review the set of instructional modules (4.0 hrs.).
2. Select appropriate instructional modules (.5 hrs.).
3. Specify resources to be added or deleted (2.0 hrs.).
4. Key punch change cards for instructional modules (1.0 hrs.).
5. Produce the required number of sets of instructional modules. (3.0 hrs.).

The total time required to complete the entire process was seven calendar days. The changes in the set of instructional modules included the following:

1. Introduction--changed the name of the unit, course and date of the posttest,

2. One additional resource added to each of 3 instructional modules and the bibliography,

3. One resource deleted from each of 15 instructional modules and the bibliography, and

4. Evaluation of Resources was changed to include or delete the appropriate resources.

Revision Indicator for Instructional Modules

When the instructor of the elementary education course reviewed the set of summary reports produced by the ISS program STAT, he reported that the volume of information contained in the reports was overwhelming. A single rank indicator for each instructional module would be an asset to the instructor and educational technologist by directing their efforts during the revision of the instructional modules. Neither the summary reports produced by the program STAT or the Revision Indicator have actually been utilized to support Phase 3 of the PIERIM model.

The rationale for the Revision Indicator was to select a number of statistics, which were available to the instructor and educational technologist, and predict the direction in which each statistic would be expected to change on the basis of criterion-referenced measurement and/or mastery models of learning. The Revision Indicator is a single composite value derived from the following statistics:

1. Mean--The posttest mean is predicted to be greater than the pretest mean. The means for Group 1 and Group 2 (see Table 10) indicate that the mean of each instructional module did in fact increase from pretest to posttest.

2. Standard Deviation--The posttest standard deviation is predicted to be less than the pretest standard deviation. The standard deviations for Group 1 (see Table 4) and Group 2 (see Table 8) indicate that for some of the instructional modules the standard deviations changed in the opposite direction.

3. Maximum Pretest Score--Learners who achieve a maximum score on the pretest are predicted to achieve mastery on the posttest.

4. Posttest Scores of Zero--Less than 5% of the learners are predicted to be in an unlearned state on each of the items related to an instructional module

5. Phi Coefficients--Each of the inter item phi coefficients for a set of items related to an instructional module are predicted to be positive. The total number of negative phi coefficients is calculated for the set of items for each instructional module.

6. Proportion of Correct Answers--The proportion of learners who answered an item correctly on the posttest is predicted to be greater than .50.

7. Alternatives for Test Items--It is predicted that on the pretest, at least one learner will select each alternative of the multiple choice items.

8. Posttest Performance--When the group of learners are divided into upper and lower 50%, on the basis of total test score, at least 80% of the learners in the upper 50% are predicted to answer the item correctly.

9. Fail/Fail Category of Performance--The mean proportion of the learners in the fail/fail category of performance was calculated for Group 1 and Group 2 and each was found to approximate .25. The proportion of learners in the fail/fail category is predicted to be less than .25.

Instructional modules and/or test items are categorized as positive (+) if there is agreement between the observed and predicted direction of change. The instructional modules and/or test items are categorized as negative (-) if there is disagreement between the observed and predicted direction of change. The negative indicators are totaled for each instructional module and the total is referred to as the Revision Indicator. Using the performance data for Group 1 and Group 2, Revision Indicators were calculated for each instructional module (see Table 15). There is substantial agreement between the rankings of the instructional modules using the Revision Indicators derived from the learner performance data for Group 1 and Group 2 ($r_s = .83$). The same three instructional modules and related test items--Measures of Central Tendency, Pretest/Posttest, and Test Items--were identified as being in need of review and possible revision. The Pretest/Posttest instructional module was the only one of the three instructional modules identified which had actually been revised during Phase 3 of the PIERIM model.

Another promising method of analyzing data from a pretest-posttest design is the McNemar Test for the significance of changes (Siegel, 1956). The learners' pretest and posttest performances can be categorized for each test item (see Table 16) into only one of the following categories:

pretest - learned and posttest-learned (i.e., 1/1)
pretest-learned and posttest-unlearned (i.e., 1/0)
pretest-unlearned and posttest-learned (i.e., 0/1), and
pretest-unlearned and posttest-unlearned (i.e., 0/0).

Learning was operationally defined as a change from an unlearned state on the pretest to a learned state on the posttest (i.e., 0/1).

TABLE 15.--Revision Indicators for Instructional Modules

Instructional Module	GROUP 1	GROUP 2
Pretest/Posttest	12	10
Behavioral Objectives	3	5
Test Items	11	10
Percentile Ranks	10	6
Measures of Central Tendency	13	12
Normal Distribution	5	8
Normal Curve	2	1
Correlation Coefficient	3	2
Correlation/Scatter Diagram	4	5
Validity	5	7
Reliability/Factors Affecting	7	7
Reliability/Interpretation	6	6
Standard Error of Measurement	2	3
Types of Tests	5	3
Test Norms/Intelligence Quotient	7	7
Standardized Test Information	5	7

Numbers represent the total number of negative (-) indicators for an instructional module

Group 1 represents the 19 learners who participated in Phase 2
Group 2 represents the 28 learners who participated in Phase 4

TABLE 16.--Proportion of learners in each category of pre-posttest learning state

Instructional Module	Item Numbers	Group 1*				Group 2**			
		1/0	1/1	0/0	0/1	1/0	1/1	0/0	0/1
Pretest/Posttest	4	.00	.26	.58	.16	.04	.32	.39	.25
	8	.05	.84	.05	.05	.00	.96	.00	.03
	28	.05	.26	.53	.21	.07	.07	.68	.18
Behavioral Objectives	7	.00	.53	.21	.26	.00	.78	.07	.14
	9	.00	.79	.05	.16	.00	.82	.04	.14
	24	.00	.58	.05	.37	.18	.36	.28	.18
Test Items	3	.37	.37	.00	.26	.14	.46	.25	.14
	20	.05	.42	.10	.42	.14	.57	.11	.18
	22	.10	.21	.53	.16	.14	.28	.36	.21
	33	.00	.63	.10	.26	.10	.28	.18	.43
	40	.05	.58	.26	.10	.28	.53	.18	.00
Percentile Ranks	17	.10	.32	.21	.37	.07	.39	.21	.32
	21	.16	.42	.21	.21	.07	.28	.36	.28
	37	.10	.00	.79	.10	.07	.39	.28	.25
Measures of Central Tendency	31	.16	.10	.32	.42	.11	.18	.25	.46
	34	.05	.10	.63	.21	.00	.11	.64	.25
	39	.10	.05	.42	.42	.21	.21	.36	.21
Normal Distribution	13	.10	.21	.47	.21	.07	.07	.36	.50
	16	.10	.32	.10	.47	.11	.14	.43	.28
	36	.05	.58	.10	.26	.00	.28	.04	.68
Normal Curve	42	.00	1.00	.00	.00	.00	1.00	.00	.00

*Group 1 represents the 19 learners who participated in Phase 2
**Group 2 represents the 28 learners who participated in Phase 4

TABLE 16.--Continued

Instructional Module	Item Numbers	Group 1*				Group 2**			
		1/0	1/1	0/0	0/1	1/0	1/1	0/0	0/1
Correlation Coefficient	35	.16	.42	.16	.26	.00	.43	.11	.46
Correlation/Scatter Diagram	41	.16	.21	.26	.37	.07	.18	.28	.46
Validity	10	.05	.53	.05	.37	.07	.50	.14	.28
	27	.16	.26	.10	.47	.14	.25	.07	.15
	29	.05	.10	.47	.37	.18	.21	.36	.25
Reliability/Factors Affecting	14	.05	.74	.00	.21	.07	.89	.00	.04
	19	.00	.10	.32	.58	.04	.18	.21	.57
	24	.05	.10	.16	.68	.11	.28	.28	.32
Reliability/Interpretation	2	.16	.37	.16	.32	.14	.43	.11	.32
	23	.10	.16	.63	.10	.14	.18	.46	.21
	32	.05	.21	.16	.58	.11	.28	.18	.43
Standard Error of Measurement	11	.05	.53	.21	.21	.07	.57	.04	.32
Types of Tests	1	.05	.74	.00	.21	.00	.68	.14	.18
	26	.16	.68	.05	.10	.11	.57	.07	.25
	38	.21	.42	.21	.16	.04	.93	.00	.04
Test Norms/Intelligence Quotient	5	.00	.74	.10	.16	.07	.68	.11	.14
	6	.10	.16	.32	.42	.04	.00	.78	.18
	15	.05	.74	.10	.10	.11	.57	.14	.18
Standardized Test Information	12	.37	.37	.10	.16	.14	.78	.07	.00
	18	.21	.47	.16	.16	.14	.46	.25	.14
	28	.05	.21	.53	.21	.07	.07	.68	.18

*Group 1 represents the 19 learners who participated in Phase 2
**Group 2 represents the 28 learners who participated in Phase 4

The McNemar Test was used to test the significance of the changes observed in the learner performance data.

Null Hypothesis. H_0: for those learners who change learning states, the probability that any learner will change from an unlearned state to a learned state ($P_{0/1}$) is equal to the probability that any learner will change from a learned to an unlearned state ($P_{1/0}$).

Alternate Hypothesis. H_1: for those learners who change learning states, the probability that any learner will change from an unlearned state to a learned state ($P_{0/1}$) is greater than the probability that any learner will change from a learned to an unlearned state ($P_{1/0}$).

Statistical Test. The McNemar Test for the significance of changes was chosen because the study used two related samples, was of a pre-posttest design, and used nominal measurement.

Significance Level. Let alpha = .001

Rejection Region. X^2 greater than or equal to 5.42.

The McNemar Test was computed for each of the instructional modules for which the number of learners changing learning states was greater than ten (see Table 17). The probability associated with each value calculated is reported for those which did not equal or exceed the critical value. While the McNemar Test is sensitive to changes in learning states, there needs to be another statistic which is sensitive to the proportion of learners who remain in an unlearned state on a posttest.

TABLE 17.--McNemar test for significance of changes

Instructional Module	Group 1	Group 2
Pretest/Posttest	.02< p ≤.05	REJECT**
Behavioral Objectives	REJECT**	.01< p ≤.02
Test Items	.001< p ≤.01	.50< p
Percentile Ranks	.10< p≤.20	REJECT**
Measures of Central Tendency	REJECT**	REJECT**
Normal Distribution	REJECT**	REJECT**
Normal Curve	N <10*	N <10*
Correlation Coefficient	N <10*	REJECT**
Correlation/Scatter Diagram	.10<p≤.20	REJECT**
Validity	REJECT**	REJECT**
Reliability/Factors Affecting	REJECT**	REJECT**
Reliability/Interpretation	REJECT**	REJECT**
Standard Error of Measurement	N <10*	.01<p≤.02
Types of Tests	.50 <p	.001<p≤.01
Test Norms/Intelligence Quotient	.001<p≤.01	.02< p≤.05
Standardized Test Information	.50<p	.10<p≤.20

* Number of learners changing learning state less than 10, McNemar Test is not appropriate.
** The Null Hypothesis is rejected.
Group 1 represents the 19 learners who participated in Phase 2
Group 2 represents the 28 learners who participated in Phase 4

CHAPTER IX

DISCUSSION OF RESULTS

The problem and the results of the study are discussed in relationship to the three separate but related parts of the study, as follows:

1. A model for the Production, Implementation, Evaluation, and Revision of Instructional Modules (PIERIM) was developed and a detailed non-empirical comparison between PIERIM and two existing system models for design of instruction was presented.

2. The implementation of the PIERIM model for a portion of an undergraduate elementary education course: (a) established the feasibility of implementing the model, (b) evaluated the learners' performance after they interacted with the instructional modules and resources, (c) refined the job descriptions for the participants of the implementation by reformulating the PIERIM (2nd edition) model, (d) resulted in recommendations concerning the contents of training materials that could be used to develop the skills required to implement the PIERIM model, and (e) provided data to estimate the cost of implementing the model in terms of design and production of the instructional modules and tests.

3. An Instructional Support System (ISS) was developed which utilized existing technology to support the implementation of the PIERIM model. The ISS development was analyzed to determine: (a) elements of the system, (b) adequacy of the ISS as measured by the output of

the system, and (c) cost estimates in terms of time and materials required to implement the ISS.

Comparison of the System Models for Design of Instruction

The comparison of Briggs' (1970) and Dick's (1969) models for design of instruction with the PIERIM model identified three potential weaknesses in the set of instructional modules produced as a result of implementing the PIERIM model.

1. The relevance of the instructional modules could not exceed the relevance of the subject matter content when compared to a specific teaching competency.

Expert opinion was used to establish the relevance of the set of instructional modules for the evaluation unit of an undergraduate elementary education course. When faculty members from the departments of Elementary Education and Educational Research ranked the set of instructional modules designed for use in the conventional classroom environment with respect to the relative importance of each instructional module, there was moderate agreement (r_s = .71) established between the ranking of the instructional modules by members of the two departments. The set of 25 instructional modules was found to represent a major portion (i.e., 50% to 100%) of the content that seven of the eight faculty members would include if they were to teach the evaluation unit.

The relevance of the instructional modules has not been established for any specific teaching competency and several of the learners questioned the relevance of the evaluation unit for elementary education majors. The learners expressed a desire for an opportunity to observe and/or apply the evaluation skills in an actual classroom situation. The relevance of the instructional modules, as perceived by a group of learners, depends upon the instructor's ability to relate the content to specific teaching competencies and then to communicate this relationship as the purpose section of the instructional modules.

2. The instructional modules, in toto, might be insufficient to achieve a specified learner behavior.

The instructor reported that the learners who had completed the 16 instructional modules in the self-instruction environment were better prepared for the remaining instructional modules which he taught than were the learners who had been taught in the conventional classroom environment. The learners who studied in the self-instruction environment needed less additional instruction on the content covered by the 16 instructional modules, asked questions which demonstrated their understanding of the content, and produced written assignments of a higher quality for the 9 instructional modules taught and evaluated by the instructor.

3. The instructional resources that were matched with an instructional module could be inadequate to achieve the desired learner behavior.

If adequacy of an instructional module to achieve a desired learner behavior is defined as the proportion of the learners achieving the stated standard of performance, then each instructional module must be evaluated separately. The proportion of learners achieving the stated standard of performance exceeds 70% for 10 of the 16 instructional modules on the posttest (see Table 11). There is not a satisfactory method for determining whether the resources identified for the instructional modules were inadequate or whether the learners did not fully utilize the resources that were made available. The original set of instructional modules was derived primarily from a content analysis of a single text (i.e., Lindvall, 1967) and the largest number of learners consistently identified this same text as the printed resource they had used to study for the posttest (see Table 9).

The problem of determining the adequacy of the resources was of sufficient importance to dictate a change in the PIERIM model. Between Phase 3--Revision of Instructional Modules and Tests and Phase 4--Implementation and Evaluation of Instructional Modules in a Self-Instruction Environment, procedures are recommended for individual and/or small group implementation of the instructional modules under controlled conditions. The controlled conditions will assure that all of the resources are available to the learners and that adequate time is provided for the learners to interact with the resources.

For 10 of the 16 instructional modules, the proportion of learners achieving the stated standard of performance on the posttest exceeded .70. The effectiveness of the instructional modules did not approach the performance levels reported by studies which have utilized system models for design of instruction (Hagerty, 1970; Mager, 1967; & Short, et al., 1968). Hopefully the effectiveness of the instructional modules produced through the implementation of the PIERIM model can be improved. It would be unrealistic to expect a system model for design of instruction which is based on selection of resources to produce instructional materials which were as effective as those produced by system models which design instructional materials specifically for a set of behavioral objectives.

The basis used to compare the three system models for design of instruction is considered appropriate for reviewing any model for design of instruction. The points of comparison for the three system models are as follows:

1. Assumptions upon which the model is based.
2. Personnel required to implement the model.
3. Intended level of application.
4. Level of analysis.
5. Activities required to be completed in the implementation of the model.

The potential user of a model for design of instruction would want to make a more detailed analysis of any system model for design of instruction before an attempt was made to apply the model to an instructional problem. At the present time the most complete description of the steps involved in the implementation of a system model for design of instruction is Briggs' (1970) most recent description of his model.

Implementation of the PIERIM Model

The implementation of the PIERIM model is discussed as it related to: (1) selection of the instructor, (2) planning requirements, (3) interaction between the instructor and educational technologist, (4) evaluation of learner performance, (5) role of the instructor, (6) role of the learner, and (7) role of the educational technologist.

Selection of the Instructor

The educational technologist had to actively solicit the cooperation of a participating instructor. The problem of securing the participation of an instructor related in part to the use of an untested system model for design of instruction and the use of instructional procedures which did not utilize the instructor as the primary resource. Instructors will probably continue to avoid empirical validation of their instructional materials and/or procedures until there is an identifiable payoff for the investment of their time and effort.

The instructor who participated in the study showed positive approach tendencies (Mager, 1968b) toward the PIERIM model in that he voluntarily continued work on the instructional modules beyond his original commitment to the study. One of the activities that he wanted to complete was the development of a revised outline for the Evaluation Unit. Prior to designing the revised unit outline, the instructor and educational technologist attempted to relate the instructional modules as resources for other instructional modules which were evaluated by the instructor. The instructor stated that he felt confident that he could implement the entire PIERIM model by himself with the exception of the ISS computer program.

Planning Requirements

The time schedule for implementation of the PIERIM model (see Figure 14) indicates the starting and ending dates for the selection of the instructor and each of the four phases of the model. The implementation of the PIERIM model indicates the need for adequate planning on the part of the educational technologist, and four critical events which were identified are:

ACTIVITY	DEC 12	DEC 19	DEC 26	JAN 02	JAN 09	JAN 16	JAN 23	JAN 30	FEB 06	FEB 13	FEB 20	FEB 27	MARCH 06	MARCH 13	MARCH 20	MARCH 27	APRIL 03	APRIL 10	APRIL 17	APRIL 24	MAY 01	MAY 08	MAY 15	MAY 22	MAY 29
SELECTION OF INSTRUCTOR	S		3		E																				
PHASE 1 - PIERIM MODEL					S		50		E																
PHASE 2 - PIERIM MODEL									S	8		E													
PHASE 3 - PIERIM MODEL										S				65					E						
PHASE 4 - PIERIM MODEL																				S	3 *	E			

DATE OF ACTIVITY

S - Start of the activity
E - End of the activity
* - Posttest for Phase 4, self-instruction portion.
Numbers represent the total number of hours required for the instructor and educational technologist.

Fig. 14.--Time schedule for implementation of the PIERIM Model

1. Selection of the instructor.

2. Phase 2--administration of the pretest.

3. Phase 4--administration of the pretest.

4. Phase 4--administration of the posttest.

The dates of the pretest for Phases 2 and 4 are critical because the instructional modules and tests must be designed and/or revised and produced prior to each of the administrations of the pretest. The administration of the posttest in the self-instruction environment is a critical event because of the coordination required for the use of the other university facilities (i.e., library, computer center and test service).

The implementation of the PIERIM model limited the resources utilized to the audio tapes and reserve books. This decision was based on the availability of the tape library and reserve room on a regular basis to the instructional staff at The Florida State University. The test scoring service and the computer facilities utilized by the ISS are similarly available to the instructional staff.

Interaction Between the Instructor and Educational Technologist

The interaction between the instructor and educational technologist was guided primarily by the instructional module worksheet (see Figure 15). The productivity of the work sessions was found to be related to the educational technologist's preparation for the session. A greater amount of information was exchanged during a work session when the educational technologist asked the instructor specific questions

CONTENT CLASSIFICATION:

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PURPOSE:

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BEHAVIORAL OBJECTIVE:

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SAMPLE TEST ITEM:

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RESOURCES:

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Fig. 15--Instructional module worksheet

rather than conducting an unstructured work session. A prototypic set of questions which the educational technologist would ask the instructor would include:

1. What competencies are you going to develop in relation to the topic described by the Content Classification?

2. What is the purpose of the learner mastering this competency?

3. How would you determine whether a learner has mastered the competency?

4. What resources would you use to teach the competency to a learner?

5. The last time we met, you stated that the learner should develop this competency. Does the behavioral objective that I have written describe the competency as you described it?

6. Can the learner's ability to perform the competency be evaluated by the sample test item?

7. Does the purpose adequately describe the reasons for a learner mastering the behavioral objective?

This series of questions was quite satisfactory for refining the set of instructional modules which were evaluated by the multiple choice test items. The educational technologist was generally unsuccessful in getting the instructor to reveal the criteria which he was using to evaluate the learner's performance on the remaining nine instructional modules.

Both the faculty members, who evaluated the instructional modules, and the learners generally agreed that the sample test items measured the stated behavioral objectives. One of the weaker elements of the interaction between the instructor and educational technologist and subsequently the instructional modules was the description of the Purpose portion of the modules. The learners, who participated in the implementation of the instructional modules in the conventional classroom environment, were critical of a perceived lack of relevance between the instructional modules and the learners' interpretation of the competencies required of an elementary school teacher. A greater effort to relate the instructional modules to specific teaching competencies would help establish the face validity of the instructional modules.

The final form of the instructional module contained the following five categories of information:

1. Content Classification--Key words which can be utilized to locate additional information related to the instructional module.

2. Purpose--A description of the behavior which the instructional module is designed to produce.

3. Behavioral Objective--Describes an observable learner behavior, method of evaluation, subject matter content, and the standard of performance.

4. Sample Test Item--Provides a sample of the type of test item which will be used to evaluate the learner's performance.

5. Resources--Provide complete identification of the resources which have been identified for the instructional module. The specific pages, which are relevant to the stated behavioral objective, are cited for each resource.

Evaluation of Learner Performance

The learners and instructor were generally satisfied with the summary of pre- and posttest performance data which they were given after each of the tests. Two specific weaknesses related to the evaluation of learner performance were identified:

1. The same test was used as both the pre- and posttest.

2. Learner performance on the pre- and posttest was used only for revision of the instructional materials and the assignment of grades.

The same form of the test was used for the pre- and posttest because of the recognized difficulty of writing multiple test items which measure the learners' performance for a single behavioral objective. Additional test items were included on each posttest to determine if the new items did in fact demonstrate item characteristics which were similar to the characteristics of the original test items that were used to evaluate the learners' performance. During the first revision of the instructional modules and tests, the additional items were a valuable source of replacement items. The goal of the instructor and educational technologist should be the development of at least two equivalent forms of the tests for each instructional module.

The research design should be changed from a One Group Pretest-Posttest Design to include a control group which does not receive the instructional treatment. This would provide a means for determining whether the pretest-posttest performance gains can be attributed to the instructional modules and/or procedures, or if the gains should be attributed to the effects of testing.

The learners during Phase 4--Implementation and Evaluation of Instructional Modules in a Self-Instruction Environment reported that they used their performance on the pretest to guide their study efforts for the posttest. The learners who achieved the standard of performance for an instructional module on the pretest were not exempt from the instruction related to the instructional module but rather were tested again on the total set of instructional modules. The administration of a total unit test for both the pre- and posttest was chosen because it greatly simplified the testing procedures and the interpretation of the performance data. The instructor and educational technologist were not that confident in either the test items or the standard of performance that they thought that learners should be exempt from instruction.

The ISS should be modified to support an individualized testing program which would exempt learners from instructional modules on the basis of the learner's pretest performance and prepare posttests for only those instructional modules on which the learner failed to achieve the stated standard of performance. There are other configurations of an ISS that could easily accommodate this change such as a computer-assisted instruction system. The testing procedures can be totally individualized utilizing the existing capabilities of the IBM 1500 system and the COURSEWRITER II programming language.

PIERIM Model (2nd Edition)

The PIERIM Model (2nd Edition) for design of instruction involves five phases of systematic interaction between an instructor and an educational technologist for the purpose of designing instructional modules for use in a self-instruction environment. The following explication of the PIERIM Model (2nd Edition) is divided into the five phases:

Phase 1--Design of Instructional Modules

Phase 2--Implementation and Evaluation of Instructional Modules in a Conventional Environment

Phase 3--Revision of Instructional Modules and Tests

Phase 4--Individual and/or Small Group Field Test of the Instructional Modules

Phase 5--Implementation and Evaluation of Instructional Modules in a Self-Instruction Environment.

The PIERIM Model (2nd Edition) refines the set of activities and operationally defines the job descriptions for the Instructor (I) and the Educational Technologist (T). The person responsible for accomplishing each of the stated activities is identified as either the Instructor (I) or the Educational Technologist (T):

<u>Phase 1--Design of Instructional Modules</u>

(I) Select content area.

(I) Write a detailed outline of the content area.

(I) Verbally state learner competencies to be developed.

(I) Verbally state the purpose for a learner achieving each competency.

(T) Write behavioral objectives for each competency.

(T) Categorize each behavioral objective within the content outline.

(T) Write/Select sample test items for each behavioral objective.

(I) Evaluate behavioral objectives and test items.

(I) List resources for each behavioral objective.

(T) Write Instructional Modules for each behavioral objective.

(T) Write evaluation instruments.

<u>Phase 2--Implementation and Evaluation of Instructional Modules in a Conventional Classroom Environment</u>

(I) Administer pretest.

(T) Prepare summary of learner performance on pretest.

(I) Implement instructional modules in a conventional classroom environment.

(T) Prepare detailed notes and outline of class lectures.

(I) Administer posttest.

(T) Prepare summary of learner performance on posttest.

Phase 3--Revision of Instructional Modules and Tests

(T) Identify changes which affect all of the instructional modules.

(I) Specify changes to be made to instructional modules and/or test items based on a review of learner performance data.

(T) Identify additional resources for the instructional modules.

(T) Match resources to each individual instructional module.

(I) Review class notes and additional resources for each instructional module.

(I) Prepare a summary for each instructional module.

(I) Prepare an audio tape of the summary for each instructional module.

(T) Revise instructional modules.

(T) Revise evaluation exercises.

Phase 4--Individual and/or Small Group Field Test of Instructional Modules

(T) Administer pretest for instructional modules.

(T) Provide learner(s) with each applicable resource.

(T) Administer evaluation of resources.

(T) Administer posttest for instructional modules.

(T) Prepare summary of learner performance.

(I) Interview learner and discuss his performance on the instructional modules.

Phase 5--Implementation and Evaluation of Instructional Modules in a Self-Instruction Environment

(I) Administer pretest.

(T) Prepare summary of learner performance on pretest.

(I) Implement Instructional Modules in self-instruction environment.

(I) Administer posttest.

(T) Prepare summary of learner performance on posttest.

(I & T) Repeat Phase 3 through Phase 5, until each Instructional Module achieves the standard set for the instructional system.

A flow diagram (see Figure 16) represents the five phases of the PIERIM Model. Just as the single implementation of the PIERIM Model resulted in changes to the model, future implementations of the model will be expected to further clarify the activities and possibly identify additional activities which must be included in the PIERIM Model.

The PIERIM Model (2nd Edition) does not differ sufficiently from the original version of the PIERIM Model to affect the comparison of the model with Briggs' (1970) and Dick's (1969) models. The major change included in the PIERIM Model (2nd Edition) is Phase 4 - Individual and/or Small Group Field Test of Instructional Modules. The PIERIM Model (2nd Edition) provides the means of minimizing all but the first of the three potential weaknesses in a set of instructional modules produced as a result of implementing the model:

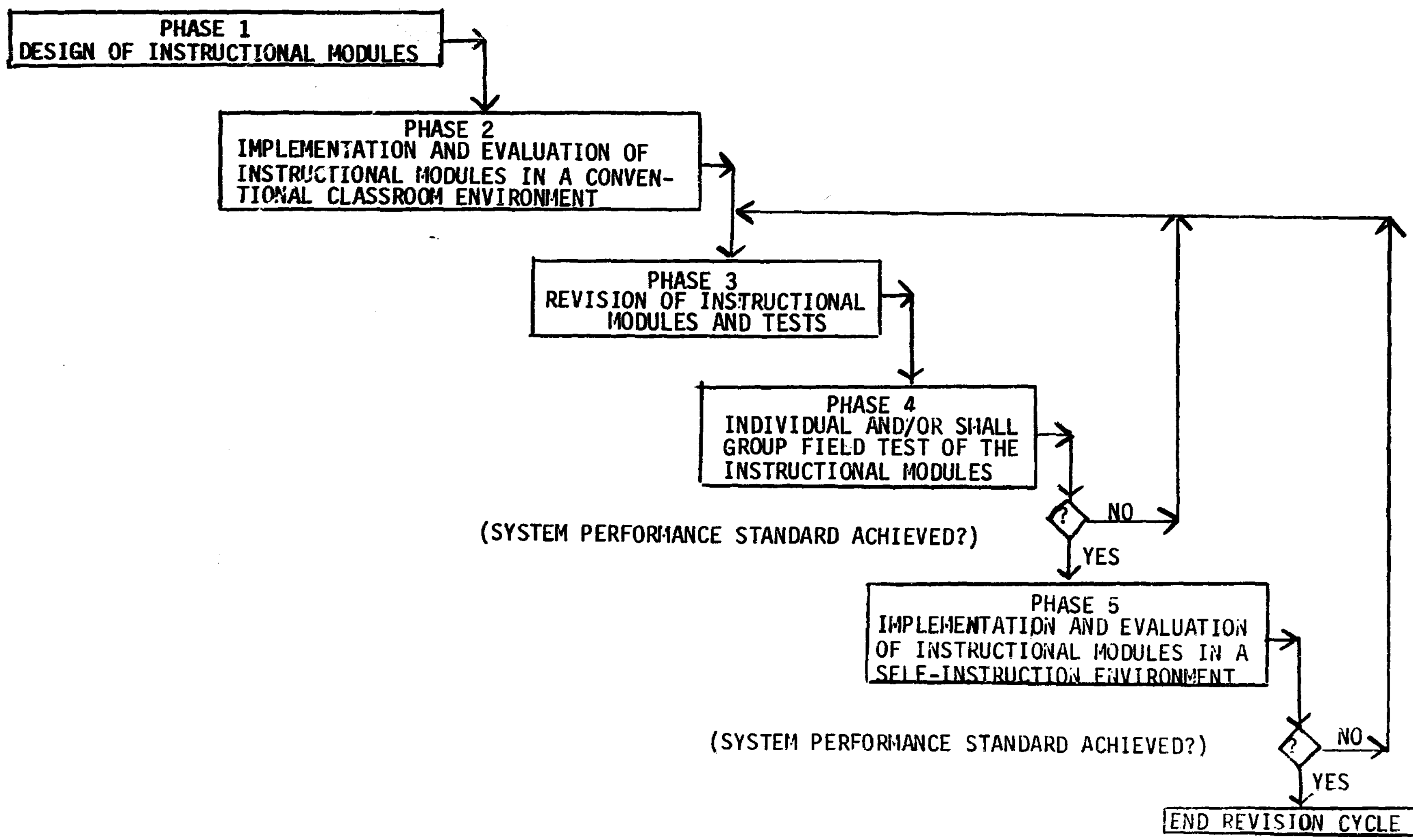

Fig. 16.--A model for production, implementation, evaluation, and revision of instructional modules (PIERIM) - 2nd edition

1. The relevance of the instructional modules cannot exceed the relevance of the subject matter content when compared to a specific teacher behavior.

2. The instructional modules, in toto, might be insufficient to achieve a specified learner behavior.

3. The instructional resources that are matched with an instructional module could be inadequate to achieve the desired learner behavior.

Role of the Instructor

The instructor is the content expert and final authority in the PIERIM model. He is responsible for defining the learner competencies to be developed, the manner in which the competencies are to be evaluated, and the resources to be used to develop the competencies. All of the work of the educational technologist is reviewed and either approved or modified by the instructor. The instructor interacts with the learners for the purpose of:

1. administering the pre- and posttest,
2. orienting the learners to the instructional modules and procedures,
3. serving as either a primary or secondary resource for each instructional module, and
4. evaluating the learners' performance for each instructional module which specifies evaluation by the instructor.

The method used to document the interaction between the instructor and the learners (i.e., tape recording of class lectures) proved to be unsatisfactory due to the large number of equipment and/or human errors associated with the activity. The educational technologist was made responsible for the documentation of the interaction in the classroom in the PIERIM Model (2nd Edition). The use of a classroom observer will be the method next used to document the interaction between the instructor and the learners.

It is perhaps unwise to generalize from a single implementation of the PIERIM model because the specific activities and/or the sequence of activities could conceivably change if the model were implemented with an instructor who was more experienced in teaching the course being developed. Based on a single implementation of the PIERIM Model, future implementation of the PIERIM Model (2nd Edition) would be facilitated if the instructor were given training in the following areas:

1. stating desired learner competencies in terms of observable behaviors,
2. relating content mastery to future teaching competencies, and
3. interacting with existing educational technology.

Role of the Learner

The learners were given three distinct roles within the implementation of the instructional modules. The learners:

1. interacted with the instructional modules,
2. recommended changes to the instructional modules and/or procedures, and
3. expressed their attitude toward the instructional modules and/or procedures.

The learners did not appear to understand that they could make a meaningful contribution to the revision of the instructional modules. One of the major tasks related to the implementation of the PIERIM Model (2nd Edition) will be the development of methods and procedures for the orientation of learners to the importance of empirical validation of instruction and their role in the validation procedures.

The use of the Evaluation of Resources (see Figure 13) resulted in an improved level of learner participation in the PIERIM Model. The simplicity of the form and the ease with which the learners could respond are considered the major reasons for the improved participation on the part of the learners. The Student Questionnaire provided a means by which the learners could respond to specific aspects of the instructional modules and procedures. The questionnaire needs to be redesigned using a more structured form of questioning and/or specified categories of responses from which the learner could select rather than construct his response. The aim of the questionnaire is to provide a communication channel between the learners, instructor and educational technologist which is readily and unambiguously interpreted.

The training recommended for the learners includes the opportunity to participate in instructional development activities on a regular and required basis. Their preparation for participation in the development activities should include:

1. system models for design of instruction,
2. demonstration of instructional methods and/or procedures, and
3. introduction to educational research methodology.

Role of the Educational Technologist

The educational technologist is required to coordinate the total set of activities related to the implementation of the PIERIM Model. The educational technologist is assumed to have mastered the skills required to implement a system model for design of instruction such as Briggs' (1970) and Dick's (1969) models. In addition to these skills, the educational technologist should receive training in:

1. operation of existing educational technology,
2. computer programming,
3. project management techniques,
4. identification of sources of information concerning available multimedia resources, and
5. non parametric statistics.

Cost of Implementing the PIERIM Model

The cost of implementing the PIERIM model reflects only the time other than actual class time that the instructor and/or educational technologist were involved in activities directly related to the implementation of the PIERIM model. The personnel costs are lower than one would expect because both the instructor and educational technologist are figured at $4.00 per hour or $320 per month for a half time graduate assistant. If the personnel costs for design of the instructional modules and tests were doubled, $8.00 per hour, then this would represent an annual salary of $15,360 for both the instructor and the educational technologist. A summary of the actual cost of implementing PIERIM (see Table 18) indicate that the total cost of designing and producing the 30

TABLE 18.--Summary of costs for implementing the PIERIM model

Phases of the PIERIM model	Design cost*	Percent	Production cost**	Percent
Phase 1 - Design of instructional modules	$248.75	32%	$ 40.85	5%
Phase 2 - Implementation and evaluation of instructional modules in a conventional classroom environment	38.23	5%	2.43	1%⁻
Phase 3 - Revision of instructional modules and tests	339.80	44%	75.61	10%
Phase 4 - Implementation and evaluation of instructional modules in a self-instruction environment	14.16	2%	8.69	1%⁺
Total cost of PIERIM model	$640.94	83%	$ 127.58	17%
Unit cost per instructional module and test items	$ 25.63		$ .17	

*Design cost for 25 instructional modules and test items
**Production cost for 30 sets of 25 instructional modules and test items

$1\%^-$ indicates less than one percent

$1\%^+$ indicates more than one percent

sets of the 25 instructional modules and tests is $768.52 or an average of $25.80 per instructional module and related test items. The design and production cost based on an annual salary of $15,360 would increase to $49.28 per instructional module and test items. The projected cost of implementing the PIERIM Model with faculty members (see Table 19) estimates the cost of designing 1, 25, and 100 instructional modules and test items and the production of 1, 30, 100, and 300 sets of the instructional modules and test items.

TABLE 19.--Cost projections for the design and production of instructional modules and test items

Number of Instructional Modules Designed	Number of Sets Produced			
	1	30	100	300
1	$ 49.28	$ 54.21	$ 66.11	$ 100.11
25	1232.00	1355.25	1652.75	2502.75
100	4928.00	5421.00	6611.00	10,011.00

NOTE: Cost estimates are based on the implementation of the PIERIM Model with faculty members. The design cost and production cost figures are $49.11 and $.17 per instructional module and associated test items.

Instructional Support System

The Instructional Support System (ISS) is operationally defined as the set of capabilities required to support the implementation of the PIERIM Model. The set of computer programs (see Appendix G) and the other resources that comprised the ISS represent just one of many possible configurations of an ISS capable of supporting the implementation of the PIERIM Model. The ISS serves three functions:

1. production of instructional modules and tests,
2. evaluation of learner performance, and
3. analysis and summary reports of learner performance data.

The specific capabilities required of the ISS for the production of the instructional modules and tests include:

1. production of any specified number of sets of the instructional modules and tests,
2. sequencing of the instructional modules and test items in any specified order, and
3. revision of the instructional modules and test items possible at the lowest practical level.

The ISS programs IMPROD and TEST possess each of the capabilities specified with the line of print being used as the basic unit for revision of the instructional modules and test items.

The cost of producing the ISS computer programs cannot be precisely determined. The educational technologist programmed, key punched and tested each of the programs. The best estimate of the total cost of producing and testing the programs is $434.00. The cost of producing sets of the instructional modules and tests are based on production runs of 30 sets of each of the materials. The production runs utilized binary source decks and program listing were not produced. The summary reports of the learners performance are based on the actual production costs associated with the implementation of the programs during Phase 4 of the PIERIM Model.

The Division of Instructional Research and Service at The Florida State University offers a test scoring and analysis service for use by the instructional staff. The characteristics required for the evaluation of the learner's performance include methods for:

1. presenting the test items,
2. recording the learner's responses,
3. evaluating the learner's responses,
4. summarizing the learner's responses, and
5. producing a record of the learner's responses.

The test scoring service provided the means of accomplishing all of the requirements with the exception of presenting the test items. The summary of the learner's responses was for the total test rather than for each instructional module separately. The response record of each learner was punched in a format which was interpretable by a computer program written in FORTRAN IV programming language and the ISS programs EVAL and STAT provided more detailed analysis of the learner's performance.

The services provided by the university library included: placement of the books identified as resources for the instructional modules in the reserve room of the library, storage of the audio tapes, and facilities for listening to the tapes. The library provided the instructor with a monthly report of the tape usage by tape number and time of day (i.e., day or night). The set of 11 tapes were checked out a total of 263 times with 28 percent of the usage occurring after 6 p.m. and 56 percent of the usage occurring the day preceding the posttest. The audio tapes were produced as summaries for the instructional modules and the learners generally found them to be a useful resource in preparing for the posttest.

The ISS supported the implementation of the instructional modules and tests in the self-instruction environment. There were never any delays in the program due to the ISS, and the learners received the summary of their performance of the pretest and posttest the day after they completed the test. The main disadvantage associated with the ISS is the relatively high cost of using the computer as the reproduction facility for the instructional modules and tests. It is possible that an alternative strategy could be implemented; using the computer to generate a master copy and then reproducing the multiple copies by more traditional methods. The major advantage of the ISS computer programs is the facility with which the instructional modules, tests, and reports can be tailored to the individual instructor's specifications.

Implications of the Study

This study adds to some but not all of the areas of research reviewed in Chapter II - Survey of Literature. The relationship and contribution of this study to the state of the art are reviewed for:

1. Current Interest in Curriculum,
2. Instructional Systems,
3. Mastery Models and Criterion-Referenced Measures,
4. Educational Technology; and
5. Innovations in Education.

Current Interest in Curriculum

The set of instructional modules produced through the implementation of the PIERIM Model for the evaluation unit cannot be considered a curriculum for the unit of instruction. The instructional modules provide a statement of the terminal objectives but fail to either describe the sequence of prerequisite capabilities or identify the initial capabilities assumed to be possessed by the learner. It is conceivable that future revisions to the PIERIM model could result in the production of instructional modules which meet the requirements for a curriculum of the content area to which the PIERIM Model was applied.

Instructional Systems

Each of the phases of the PIERIM model and each of the ISS computer programs were found to correspond to at least one of the five general subsystems of an instructional support system (see Figure 1):

1. Phase 1 of the PIERIM model and the ISS programs IMPROD and TEST correspond to the Design/Selection of Instructional Materials Subsystem,

2. Phase 2 and Phase 4 of the PIERIM model correspond to the Implementation subsystem,

3. ISS programs EVAL and STAT correspond to the Evaluation Subsystem,

4. Phase 3 of the PIERIM model corresponds to the Revision Subsystem, and

5. ISS programs EVAL and STAT and the interface established between the test scoring service and the ISS programs represents a weak correspondence to the Information Management Subsystem.

Although the ISS developed for this study is a relatively simple system, it does relate to a more general instructional support system sufficiently to be referred to as an ISS. The major advantage of the ISS designed to support the implementation of the PIERIM model is that only existing technology was utilized and that technology is generally available to the staffs of teacher training programs.

System Models for Design of Instruction

The PIERIM model was proved capable of transforming the content of an elementary education course into a format (i.e., instructional module) which is compatible with an individualized teacher training program. The implementation of the PIERIM model was accomplished with the assistance of an instructor from the Department of Elementary Education at The Florida State University. Elementary education majors interacted with the instructional modules and resources and performance indicates that the instructional modules and/or procedures are moderately effective in producing the desired behavioral changes in the learners. The major modification included in the PIERIM model (2nd Edition) is the inclusion of the procedures for individual and/or small group field test of the instructional modules.

The PIERIM model is a contribution to the field of system models for design of instruction because:

1. PIERIM is a selection model as opposed to a design model, and
2. PIERIM is an interactive model which specifies activities for the instructor (i.e., content expert) and educational technologist for the implementation of the model.

The assumptions upon which the PIERIM model is based are specified and the potential user of the model can decide for himself if the PIERIM model is applicable to his instructional problem. The new assumptions are:

1. Performance-based teacher training programs require a variety of instructional systems, one of which could be concerned primarily with enabling learners to master relevant cognitive skills.

2. A significant portion of the cognitive skills which comprise existing pre-service teacher training programs is applicable in a performance-based teacher training program.

3. The instructor is a subject matter expert.

4. The instructor is primarily a selector rather than a designer of instruction, and

5. Existing system models are best suited for design of instruction rather than selection of instruction.

The comparison of the PIERIM model with Briggs' and Dick's models provides the teacher educators with a frame of reference that is applicable for reviewing other methods for designing instruction:

1. assumptions upon which the model is based,

2. personnel required to implement the model,

3. intended level of application,

4. level of analysis, and

5. activities required to be completed in the implementation of the model.

The PIERIM model could be considered as a potential method of training faculty members in the use of a systems model for design of instruction. After the study was completed, the instructor stated that he felt confident that he could implement the PIERIM model by himself if an educational technologist would assist with the Instructional Support System. It is estimated that one educational technologist could work with three or four faculty members simultaneously in the implementation of the PIERIM model if the units of instruction were not more than three weeks in length.

Mastery Models and Criterion-Referenced Measures

The ISS programs EVAL and STAT were specifically designed for use with criterion referenced measures and a pretest - posttest evaluation design. Preliminary work related to the development of a Revision Indicator provides one method of ranking instructional modules which are evaluated using criterion-referenced measures. The McNemar test appears to be useful for evaluating changes in learner performance from pretest to posttest. The McNemar test is insensitive to the number of learners who remain in an unlearned state on the posttest.

Instructional Packages

The instructional modules produced through the implementation of the PIERIM model do not meet all of the characteristics of an instructional package (Ubben, 1970). The instructional modules are best classified as learning guides rather than instructional packages. The specific characteristics which prevent the instructional modules from being classified as instructional packages are:

1. Each learner did not receive a complete set of the instructional modules and resources nor were there complete sets of the materials packaged for use by the learners for each instructional module.
2. The media choice was limited to printed materials and audio tapes for the instructional modules.
3. Evaluation devices and self tests were not made available to the learner on the instructional module level.

Educational Technology

The ISS programs and the computer provided a means for producing instructional modules and tests. Even though the cost is greater than producing the materials by traditional methods, the advantages of speed and ease of revision the materials make the methodology competitive with traditional means. The possible solution of utilizing the computer to produce a master copy and then reproduce additional copies by a more traditional means could possibly reduce the cost and yet retain the advantages of the computer generated instructional modules and tests. The method of programming each instructional module and test item as a separate FORTRAN IV subroutine greatly increased the flexibility of the ISS programs.

The popularity of the audio tapes cannot be interpreted as meaning that the tapes were necessarily effective in producing the desired changes in learner behavior. The popularity of the audio tapes supports the findings of Meene, et al. (1969) in that the general reaction of the learners to the tapes was favorable.

Innovations in Education

The problems associated with the implementation of innovative changes in an instructional program of higher education (Mayhew, 1967) were encountered in the present study. The most critical activity of the study was securing the cooperation of the instructor for the implementation of the PIERIM model. Faculty members of the teacher training program appeared to be resistant to changes in their instructional program and/or procedures. Teacher training programs should consider the potential of utilizing advanced graduate students to prepare the instructional modules and tests required to support an individualized preservice teacher training program. The use of the graduate student reduces the personnel costs to a minimum.

CHAPTER X

IMPLICATIONS FOR FUTURE RESEARCH

The implications of the study for future research are reviewed as they relate to the areas of: teacher training systems, implementation of the PIERIM model, and the Instructional Support System. There are many more major research questions related to the areas indicated but the discussion will be limited to those areas which would be beneficial specifically to future implementations of the PIERIM Model (2nd Edition).

Teacher Training Systems

The implementation of the PIERIM model focused on a need for research related to both teacher training systems and the PIERIM model. Teacher training systems seemingly have not set up procedures and reward systems which would encourage instructors and/or learners to participate in the empirical validation of instructional materials and/or procedures. The need exists for research related to the development of procedures and reward systems which place an emphasis on the design and validation of instructional equal to that currently placed on other research activities and publications.

One set of procedures which might be considered is:

1. Establish within the teacher training program the facilities and staff of educational technologists to assist faculty members with the

development of instructional materials and/or procedures for an individualized teacher training program.

2. Require that all education majors participate on a regular basis in the development of instructional materials and/or procedures for the teacher training program.

3. Release instructors from regular teaching assignments for the expressed purpose of designing instructional materials in their areas of specialization, and

4. Include the development and documentation of the effectiveness of instructional materials as one of the requirements for promotion within the teacher training system.

Implementation of the PIERIM Model

Several specific areas of research are suggested which relate to the implementation of the PIERIM model. Six major areas of research can be considered.

Behavioral Objectives

The implementation of the PIERIM Model resulted in the production of a set of behavioral objectives for the evaluation unit of an elementary education course. Research is needed to determine whether these behavioral objectives are the same as a set of behavioral objectives which would be derived through a job analysis based on the tasks actually performed by elementary school teachers. If discrepancies exist between the two sets of behavioral objectives, are there methods for predicting the discrepancies for other content areas?

Standards of Performance

Research is needed to determine the nature of the relationship between the standard of performance attained by a learner and the learner's performance on both immediate and delayed retention tests.

Revision of Instructional Modules

There is a need for the development of a simplified method of ranking instructional modules as to their relative need for revision and a rationale for terminating the revision process for an individual instructional module. The preliminary work related to the Revision Indicator could possibly be expanded to include subjective ratings by the instructor and/or the learners. Research related to the use of minimum change values in the calculation of the Revision Indicator rather than the simpler dichotomy which classifies observed changes as being either in a specified direction or in the opposite direction could possible improve the sensitivity of the Revision Indicator.

A rationale is needed for selecting the criteria to be used to terminate the revision process for an instructional module. Should the criteria be the same for instructional modules produced by a selection model and a design model? The criteria of available time and financial resources between successive implementations of the instructional modules must be considered when the design goals of an instructional system are established.

Basic Unit of Instruction

The basic unit used by the PIERIH model for development and revision was the instructional module. The basic unit used for evaluation of learner performance was the set of 16 instructional modules. It is necessary and/or desirable to use the same unit of instruction for development, implementation, evaluation and revision. Research is needed which would investigate the relative efficiency of using different basic units of instruction (i.e., training program, course, chapter, task, instructional module, etc.) as the basis for the development and revision of instructional materials.

Implementation Strategy

Does the strategy used to implement the instructional modules affect the learners' performance? If the same set of instructional modules were presented to three groups of learners:

Group 1 - the learners would be given a pretest, interact with the instructional modules and resources, and be given a posttest.

Group 2 - the learners would be given a pretest, exempted from instructional modules on which the standard of performance was achieved, interact with the instructional modules and resources, and be given a posttest.

Group 3 - the learners would be given the instructional modules and required to achieve the standard of performance for each instructional module, allowed to interact with all of the instructional modules and resources, and be given a posttest.

How would the procedures used to implement the instructional modules affect the learner's performance on the immediate or a delayed retention test?

Trait - Treatment Interaction

Approximately 70% of the learners in both groups indicated that they would select a course taught with instructional modules rather than the same course taught without instructional modules. Can a common characteristic or set of characteristics be identified for the 30% of the learners who preferred a course without instructional modules?

Assume that a common set of characteristics were identified for the learners who preferred traditional instruction to the use of instructional modules and self-instruction. If the set of characteristics did in fact identify those learners who would respond in a similar manner then the challenge to the instructor and educational technologist would be to determine methods of accommodating the individual differences within the self-instruction environment. Redundancy of instructional resources is one possible alternative but it is questionable if this method is economically defensible. An alternative area of research would be the orientation of learners to the needs for and purposes of instructional research and the validation of instructional materials. Would it be possible to design an orientation which allows each learner to ask any questions which he felt were relevent and of concern to him? What procedures can be built into a self-instruction environment which will facilitate communication between the instructor and the learner?

Instructional Support System

The research needed in relationship to an ISS can be classified into two areas:

1. production of the instructional modules and tests, and
2. distribution systems for ISS type computer programs.

Production of Instructional Modules and Tests

The cost of producing 30 sets of the instructional modules and tests for the evaluation unit was determined to be approximately $2.03 per set of 25 instructional modules and tests. The major portion (i.e., 91%) of the cost is related to the use of the computer as the production facility. Alternative combinations of existing technology need to be considered in order that the cost of producing the instructional modules and tests can be reduced. Possibly the computer should only be used to produce a master copy of the instructional modules and tests and then alternative methods of producing multiple copies of the materials should be considered. More efficient FORTRAN IV programming techniques could possibly improve the efficiency of the ISS computer programs.

Distribution of ISS Type Computer Programs

The basic unit of the ISS computer programs is the FORTRAN IV subroutine. Research is needed to determine which methods are currently feasible, the tradeoffs between alternative methods,and the costs involved in implementing each of the methods. One possible method of exchanging subroutine programs would be the establishment of a common time sharing system for all teacher training institutions. The time sharing system would serve as a library of instructional modules and test items, each written as a FORTRAN IV subroutine, and then each participating teacher training institution would have access to the most recent version of each program as it was produced.

Each of the areas of needed research that have been discussed are relevant to future implementations and revision of the PIERIM Model (2nd Edition). The PIERIM model was designed specifically for use by educators involved in the preservice teacher training programs. All educators are encouraged to consider system models for design of instruction as the underlying model for teacher training. When teacher training programs have been designed through the application of system models for design of instruction, then future teachers can be told to teach as they were taught.

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