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ABSTRACT

Reported is a study designed to develop, evaluate, and revise competency-based materials in science methods education for elementary school teachers. Data were collected and analyzed relative to four questions: What are the outcomes of competency-based instruction in science at Central Michigan University? Do competency-based teacher education (CBTE) science students differ from non-CBTE students in achievement, perceptions of achievement support, attitudes and directed teaching performance? Do CBTE students who have concurrent field experiences differ from those who do not in achievement, perceptions of achievement support, attitudes toward teaching science, and performance in directed teaching? What do self-ratings of achievement measure? Conclusions and recommendations are given. There are two appendices to this final report. (They are listed as separate documents.) Appendix A contains science modules. Appendix B contains copies of the assessment instruments. (PEB)

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A Cooperative Program for Developing a Competency-Based Elementary Teacher Preparation Module in Science Education by University and School Personnel

Final Report
to
Michigan Department of Education

Central Michigan University
Mt. Pleasant Public Schools

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Early Childhood and Elementary Education

February 1975

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PREFACE

In October, 1973 the State Department of Education's request for proposals (RFP) was received by the Dean of the School of Education at Central Michigan University. The RFP was discussed in a School Administrative Council meeting where the Chairmen of Early Childhood and Elementary Education and Secondary Education expressed an interest in a further study of the document. After subsequent discussion between these two men, the Dean, and other interested parties it was decided that the Department of Early Childhood and Elementary Education would respond to the RFP.

A meeting in East Lansing to discuss the RFP was attended by several individuals to gain further insight into the proposal. The Chairman of Early Childhood and Elementary Education presented the matter to a representative from Alma College who expressed an interest in a cooperative venture which also would include Mt. Pleasant and Alma Public Schools.

After a number of conversations with the representative from Alma College and with less than a week before the RFP was due, it was decided that the Alma Public Schools were unable to participate which meant that Alma College would also have to withdraw from the proposal.

Earlier conversations with the Assistant Superintendent of Schools in Mt. Pleasant assured CMU of their interest and willingness to cooperate in the proposal. (See letter in appendix.) With the withdrawal of Alma College and the Alma Public Schools, this action left the proposal to be worked out between CMU and the Mt. Pleasant Schools. Further conversations were held with the Mt. Pleasant Assistant Superintendent to decide ways in which the project would draw upon elementary children, teachers and schools.

With just a few days remaining before the November 30 RFP due date, the proposal was written by the Chairman of Early Childhood and Elementary Education. The chairman along with an elementary principal from Mt. Pleasant appeared before the proposal selection board in Lansing in December 1973 to present their plan and to answer any related questions. About midway into January word was received from the State Department of Education that the Elementary Science Project was among the four selected to be funded at $25,000. The project was designated to run from February 1, 1974 to February 1, 1975.

Such was the conception and birth of the project. This report describes its brief life span. It is important to place the life span of the project in the context of the total CBTE effort in science education at CMU. The development of a CBTE Science Methods component to the elementary program began prior to the initiation of the project. Clearly, as the report will show, it must be carried on to achieve more than superficial success.

I

INTRODUCTION

College instructors engaged in the preparation of elementary teachers do not have the time nor the opportunity afforded Philip Jackson[1] to spend hours, days, weeks or months in a classroom "living" with children. Many do manage to visit a number and variety of classroom settings where they attempt to "keep in touch" with the real world of teaching. The curriculum on view in typical elementary classrooms usually consists of reading, language arts, mathematics, social studies, seat and review work in these areas. If the observer is lucky, perhaps he will see something in science, fine arts and physical education. While the literature[2] is replete with research focusing on elementary school science, it has been this researcher's observation that teachers in many elementary schools teach very little, if any, science. At best science in the elementary schools is taught incidentally, rather than systematically. Only the introduction of the "kit" approach in the "new" sciences (AAAS, SCIS, ESS, et. al.)[3] has kept elementary school science from virtually being buried among the also-rans (or "frills") in an elementary school curriculum. The "kit" approach, introduced in the early 1960's, has not been universally adopted, although it is widely discussed. Elementary schools all over Michigan use and continue to use out-dated or insufficiently revised publications and practices in science instruction. This important subject ought not to be interpreted by children as "Science is what comes at eleven o'clock on Tuesdays and Thursdays."[4]

[1]Jackson, Philip. Life in Classrooms (New York: Holt, Rinehart and Winston, 1968.

[2]Dunfee, Maxine. Elementary School Science: A Guide to Current Research, Washington.

[3]AAAS - Science A Process Approach; SCIS - Science Curriculum Improvement Study; ESS - Elementary School Science.

[4]WILKIT, W-42 Inquiry In Elementary Science (Ogden, Utah: Weber State University, April, 1972), p. 2.

There is some excellent science instruction being offered in elementary schools. However, it is neither uniform, nor behaviorally based. The State Minimal Performance Objectives in Science were prepared in order to provide each elementary school child with basic science experiences, skills, and knowledge. Universities must now work to integrate the State Minimal Performance Objectives in Science with behaviorally prescribed and measurable objectives in science taught for prospective elementary school teachers. The "new" science programs in the elementary school have "reinforced the importance of this level of science in the total precollege science experience and have set the stage for further curriculum at this level."[5]

A primary goal of college departments of elementary education is the preparation of elementary teachers, but the nature of the experience undergone by students and how these are translated into the elementary school classroom depends entirely upon how well the objectives are understood and interpreted by the instructor and his students in each college methods class.

> "Most preparation programs in teacher education are characterized by their lack of unified, cohesive, directed efforts. There is a distinct lack of interrelatedness as many individual faculty in several departments each go their separate ways."[6]

The Department of Early Childhood and Elementary Education is convinced that the old doctrine of teacher training is neither sacred nor free from glaring shortcomings. Therefore, it proposes to develop and implement a study of teacher preparation in

[5]Rutledge, James A. What Has Happened to the "NEW" Science Curricula? Educational Leadership; (Washington: Association for Supervision and Curriculum Development, Vol. 30, No. 7, April 1973), p. 603.

[6]Houston, W. Robert. Competency-Based Teacher Education (University of Houston, February, 1972) p. 6.

science education which would be more relevant to the "Common Goals of Michigan"[7] and the movement of "more than thirty states"[8] considering performance based teacher education as a means for licensing (certifying) teachers.

The State has provided the handle for the universities and public schools and the "new" programs have kept the interest in science high. Now it is time to turn the handle to open the focus on the kind and quality of the objectives which universities and schools can cooperatively develop utilizing the State's Minimal Performance Objectives.

STATEMENT OF THE PROBLEM

The general problem to which this project was addressed is the development of a competency based college level elementary science education methods experience (or course). Its major theme was cooperation between University faculty members and elementary school teachers. Competencies were identified and organized in a modular format. State Minimal Performance Objectives in Elementary Science were utilized in the planning. Modules were generated on the assumption that undergraduate pre-service students were the target population.

The goal of this project is a preparation (pre-service) model in science education based on stated competencies and utilizing State Minimal Performance Objectives in Science. It was hypothesized that a set of competencies for elementary teaching candidates would be generated which would result in (a) greater achievement in the science methods course, (b) more positive attitudes toward the teaching of science as a process, and (c) a more successful student teaching experience.

[7] The Common Goals of Michigan, Michigan Department of Education, Lansing, September, 1971.

[8] Education U.S.A. National School Public Relations Association, Washington, November 12, 1973, p. 61.

The focus of the problem was selected to maximize the mutual benefits to the University and the cooperating school districts. First, the prior science education experience of participants was a key factor. Second, the problem was devised to allow more teacher candidates to get into the public schools prior to their student teaching experience. Third, it afforded the Public School teachers and University faculty opportunities to work together on a subject which holds continuing concern and interest for both groups. Fourth, it provided the schools with a built in consultancy in science and related to newly adopted programs. Fifth, it provided Central Michigan University an opportunity and the means to incorporate the State Minimal Performance Objectives in Science into the college level science education methods courses.

PROJECT PLAN

Project implementation involved four phases which are briefly described below.

Phase 1: Development

During the eight (8) week period from January 14, 1974 to March 9, 1974, the Project Team of University faculty and Public School teachers was formed and met twice a week to identify competencies and create modules for an elementary science education experience. This phase included the utilization of outside consultants.

Phase 2: Initial Tryout

During the eight (8) week period from March 18, 1974 to May 3, 1974, modules designed by the Project Team were implemented in five (5) sections of the University's elementary science methods course.

Try-outs of the project materials were designed so that the competency-based approach could be evaluated against a traditional approach and so that the element of field experience as a part of the competency-based could be

Phase 2: Initial Tryout (Cont'd.).

evaluated. Following this comparative design, three (3) experimental CBTE groups were formed. CBTE 1 was composed of students who worked through project modules but participated in no field experiences. CBTE 2 was composed of students who worked through project modules and observed at least once in an elementary classroom. CBTE 3 was composed of students who worked through project modules, observed in an elementary classroom, and participated in a mini-teaching experience with elementary pupils. The traditional group was taught in the University classroom using text materials, lectures, demonstrations and discussions.

During this phase, the Support Team of Public School teachers willing to have teacher candidates observe and tryout their teaching skills was organized. Support Team members provided informal feedback to the Project Team on their observations of teacher candidates during field experiences at joint meetings which were held during this phase. Based on such feedback the Project Team began revisions and continued development of project materials.

At the end of this phase students participating in the project were assessed on the following variables: (a) self-rated achievement, (b) perceptions of achievement support, and (c) attitudes toward teaching science.

Phase 3: Revision

During this phase from May 13, 1974 through July 22, 1974, two (2) University faculty members continued the revision of project materials. Feedback from students participating in three (3) week and six (6) week sessions of the science methods course were used as a basis for revision. In addition, modules were critiqued by outside experts.

Phase 4: Initial Tryout Follow-up Evaluation and Tryout of Revisions

During the period of August 26, 1974 to December 6, 1974, revisions were implemented in five (5) sections of the University's elementary science methods course. These students were assessed on revised measures of: (a) self-rated achievement, (b) perceptions of achievement support. Two new measures, (c) attitudes toward self-as-a-teacher and (d) attitudes toward self-as-a-science, teacher were administered.

In addition, students in the Initial Try-out groups were evaluated on their ability to plan and implement instruction during a second field experience, i.e., student teaching. Students were rated by supervising teachers on performance-based checklists relating to planning and implementing instruction.

DEFINITION OF TERMS

For purposes of the project the following terms were defined as follows.

Competency-based Instruction

Teaching and learning activities designed to afford students the opportunity to acquire a set of explicitly stated skills, knowledge, and attitudes.

CBTE Groups

Groups of students who use competency-based project materials during their science methods course.

CBTE 1

A group which used project materials but had no conjoint field experience.

CBTE 2

A group which used project materials and observed in elementary science classrooms.

CBTE Groups (Cont'd.)

CBTE 3

A group which used project materials, observed in elementary classrooms, and taught a mini-lesson in an elementary classroom.

Traditional Group

Students whose skills, knowledge, and attitudes related to science methods were developed in a traditional classroom emphasizing the use of lecture, discussion, text, and demonstrations.

Project Team

Seven (7) Public School teachers and four (4) University faculty who participated in identification of competencies and materials development.

Support Team

Seven (7) Public School teachers who participated in setting up and evaluating observation and mini-teaching experiences of students in CBTE 2 and CBTE 3 groups.

Field Experience I

Experiences of CBTE 2 and CBTE 3 groups which occurred concurrent with science methods course.

Field Experience II

Directed teaching experiences of students in CBTE and traditional group students.

Self-Rated Achievement

A set of ratings in which students in the science methods course rated their achievement on course goals. Two (2) forms were used in this project. The Initial Try-out form involved twenty (20) goal statements. The Revised Try-out form listed twenty-five (25) goal statements.

Perceptions of Achievement Support

A set of student ratings of the contribution to course achievement of various aspects of instruction. The Initial Tryout form involved ratings of the following aspects of instruction, printed materials, instructor influence, interactions with other students, personal effort. The Revision Tryout form required students to rank activities or course aspects which made an important contribution to achievement. Thirteen (13) variables were listed.

Attitudes Toward Teaching Science

A set of semantic differential measures of students' attitudes toward teaching science as a process and as an organized body of knowledge.

Attitudes Toward Self-As-A-Teacher

A semantic differential measure of students' attitudes toward themselves as teachers.

Attitudes Toward Self-As-A-Science Teacher

A semantic differential measure of students' attitudes toward themselves as science teachers.

Initial Try-out

The use of project materials with three (3) classes of students during the Winter Semester, 1974.

Revision Try-out

The use of project materials with five (5) classes of students during the Fall Semester, 1974.

ASSUMPTIONS

The project was based on the following set of assumptions about competency-based teacher education.

1. Competency-based instruction in teacher education is not a neatly packaged training program which can be transplanted from one campus to another. It is not content, but rather a set of processes and procedures for an inquiry-oriented approach to teacher preparation. For this reason modules developed at other universities and other contexts can be stimulating and suggestive, but they are not substitutes for the process which is the key.
2. As an inquiry-oriented approach to teacher education, competency-based instruction focuses on making and examining hypotheses, not stating and administering prescriptions. While there has been much confusion between CBTE and a prescriptive, behavioristic approach to instruction, the two are not identical. Similarities are superficial rather than substantive. CBTE is a process for generating causal relationships between teaching and learning; behavioristic psychology constitutes a particular set of explanatory concepts and relations which seem to have some degree of validity. CBTE is a way of asking the question, what competencies should an effective teacher possess? It is a set of search strategies, not an answer to the question.
3. The search strategies involved in CBTE involve several key elements. Some of these may be listed.
    a. Direct teacher influence is a complex treatment which must be represented by knowledge, attitudes, and cognitive and psychomotor skills. It is not reduced to any one of these.
    b. In addition, teacher influence may be indirect. Much of the teacher's influence on pupil learning is mediated by such factors as school and classroom organization, community and parental values, and curriculum structure. CBTE generated hypotheses about teacher influence on learning do not ignore these factors.
    c. Legitimate hypotheses about how teacher influence affects pupil learning may be generated by teachers, parents, and pupils as well as by teacher educators.
4. As an inquiry strategy, a CBTE approach recognizes the value error in making progress. Hypotheses about teacher influence which are not supported are accepted as informative feedback.
5. Finally, since CBTE involves commitment to the process of acquiring knowledge about teacher influence and not the substance of that knowledge, it is flexible and open to change.

LIMITATIONS

The limitations of the project flow to some extent from the very nature of CBTE. An attempt has been made to delineate some of these limitations.

1. Since CBTE is an on-going process, any project with defined time parameters can reflect only a part of the process. Since this project does not cover the beginning of the CBTE effort in science education at Central Michigan University, and since the process has no definitive end, it is not possible to say how accurately the project represents the total effort.
2. The hypotheses about teacher influence described in this report were generated by a group of University faculty and Public School teachers working together for the first time under a very compressed time frame. It seems likely that this initial effort will result in hypotheses which need much revision.
3. Since CBTE focuses on hypotheses about teacher influence, the ultimate test of these hypotheses rests on data regarding the success of CBTE-trained teachers in job situations. The feedback from course achievements and the simulations and role-playing of mini-teaching and student teaching must be viewed as an incomplete set of data at best. No conclusive answers can be provided about the hypotheses generated in the context of the current project.
4. The elementary science education CBTE effort at Central Michigan University is limited by the nature of the students enrolled in the program. Generalizations about the success or lack of success in the current situation should be applied cautiously to populations which are similar and not at all those which are dissimilar. Some of the characteristics which seem salient are the following:
    a. More than 80 percent of the students are female.
    b. More than 75 percent of the students come from suburban and rural communities, and are interested in returning to such communities to teach.
    c. Fewer than 1 percent of the students are minority group students, although a somewhat larger group is interested in teaching minority group pupils.
    d. Less than 25 percent of the students have a major and/or minor in the sciences.
    e. The most frequent majors and/or minors are Special Education, English, and Social Science.

II
REVIEW OF RELATED INFORMATION AND LITERATURE

The focus on detailed specifications of instructional objectives probably got a boost as the result of efforts of early twenty-century curriculum pioneers, Franklin Bobbitt and W. W. Charters, along with the then leading educational theorist E. L. Thorndike, who stated, "whatever exists at all exists in some amount."[1] By 1950 Ralph Tyler was stating that the study of an educational program in a systematic fashion must begin with the thought at what the educational objectives are aimed. In the early 1960's Benjamin Bloom and his associates labored at the task of identifying and classifying certain thought processes which were representative of student behavior sought by schools. Later B. F. Skinner weathering criticism focused on teaching theorized that "the whole process of becoming competent in any field must be divided into a very large number of very small steps, and the reinforcement must be contingent upon the accomplishment of each step."[2]

In the late 60's and early 70's, the focus of a movement which had been primarily concerned with the instruction of school children shifted to the preparation and training of teachers. This shift was in evidence when in 1967 a national effort to improve undergraduate and inservice teacher education programs for elementary teachers was the focus of requests for proposals by the U.S. Office of Education.

Of the nine (9) proposals funded from the eighty (80) which were submitted three (3) have some bearing on this study. These three (3) proposals were produced by Florida State University, Michigan State University and the University of Georgia. The Florida

[1]Thorndike, E. L. National Society for the Study of Education, The Measurement of Educational Products, Seventeenth Yearbook, Part II (Bloomington, Ill: Public School Publishing Company, 1918), p. 16.

[2]Skinner, B. F. The Technology of Teaching (New York: Appleton-Century-Crofts, Inc., 1968), p. 21.

State University Model Program for the Preparation of Elementary School Teachers, headed by G. Wesley Sowards undoubtedly had some bearing on the Florida Catalog of Teacher Competencies. The Michigan State Behavioral Science Elementary Teacher Education Program was directed by W. Robert Houston in which Robert G. Oana, the Director of this Elementary Science Project was a team member. Houston left Michigan State University in 1969 to go to the University of Houston where he had the responsibility for the University of Houston Competency-Based Teacher Education Program.

The Georgia Education Model Specifications for the Preparation of Elementary Teachers, headed by Charles E. Johnson, Gilbert F. Shearron and A. John Stauffer, had Sandra Harris, who was a Project Team member of the CMU Elementary Science Project, working as a graduate assistant.

The Georgia Model, through the efforts of Sandra Harris, served as a point of reference for the CMU project. The Georgia Model focused on four (4) classifications: 1) Specifications for the Selection of Candidates for the Model Program, 2) Specifications for Teacher Performance, 3) Specifications for Program Evaluation and 4) Specification for Implementation. From these four (4) classifications the Project Team drew upon information related to performance specifications in cognitive processes.

The Florida Catalog of Teacher Competencies provided the Project Team with a ready list of competencies in science education from which to draw upon. This very extensive offering of competencies greatly reduced the Project Team's task of "creating" the kinds of competencies desired. It provided a means for review, analysis and selection of behaviors. Those behaviors which were not included or which were unique to the CMU project were prepared by Sandra Harris and Jack Evans, instructors of ELE 340 - Science and Social Studies in the Elementary School course.

Finally, the University of Houston Model provided a number of ideas for the Project Team. The University of Houston was visited by Jack Evans who discussed the CMU Project with Robert Houston who offered several suggestions for the CMU Project. In addition Evans returned with a number of red-covered modules prepared by the University of Houston which seemed to have relevance to the CMU Project. Additional modules were ordered from Houston and elsewhere as the CMU Project progressed. These modules which served as a point of reference or which became part of one or more CMU Modules are included in the bibliography.

From the beginnings of the general CBTE movement to its present specific format at CMU, however, it has been apparent that the essence of CBTE had to be a process-oriented, inquiry strategy, rather than an authoritative, prescriptive approach to describing what competencies effective teachers should have. Karl Massanari reiterated this point in a recent issue of the Bulletin of the American Association of Colleges for Teacher Education.

> CBTE does not tell you what the role of a teacher should be, what competencies he or she should possess, what instructional strategies to use in the training program, or what levels of mastery a teacher should have to demonstrate competency.... CBTE does not claim that a particular set of competencies determined for a particular training program answer definitively what teaching competence is. But it does imply that that particular set of competencies will be viewed as hypotheses to be tested and validated, and that the original set will be modified in the light of experience.[3]

[3]Massanari, Karl. A.A.C.T.E. Bulletin, Vol. 27, No. 8, p. 5.

The position that competency statements in teacher education programs be viewed as hypotheses is based in the assumption that there is no present empirical basis for listing teacher competencies. This assumption is strongly supported by an analysis of the research on the relation between teacher behaviors and pupil learning.[4]

Heath and Nielson examined forty-two (42) studies in which eighty-four (84) teacher behavior variables had been studied for their influence on pupil learning. In addition, they summarized previous reviews of research into the relationship between teacher characteristics and student achievement. The results of their analysis led Heath and Nielson to conclude "that an empirical basis for performance-based teacher education does not exist."[5]

In summary, the movement to enhance student learning by specifying instructional objectives in behavioral form spread to the university level and the preparation and training of teachers in the form of a movement labelled "competency-based teacher education." The focus of programs in this movement has been to specify as instructional objectives of the training program teacher behaviors which result in pupil learning. However, the status of research in this area is such that no firm empirical basis for such specifications exists. Consequently the competency statements of CBTE programs have been viewed as hypotheses which must be tested and validated.

[4]Heath, Robert and Mark Nielson, "The Research Basis for PBTE," Review of Educational Research, Vol. 44, No. 4, pp. 463-484.

[5]Ibid., p. 475.

III
DEVELOPMENT, EVALUATION AND RESEARCH PROCEDURES

This multi-phase project encompassed several specific problems which can be grouped into three general classes: (a) the development problem of generating new instructional materials and strategies, (b) the evaluation problem of determining the extent to which materials and strategies had their desired effects, and (c) research problems concerned with the comparative effects of different levels of field-experience during pre-service preparation of teachers and with the validity of self-reports of achievement. The procedures for attacking these classes of problems have common elements and considerable overlap. Consequently, they will not be considered separately.

INSTRUCTIONAL MATERIALS AND STRATEGIES

The Project Team met 12 times during the Winter Semester, 1974, three times with the Support Team. The central purposes of the Project Team meetings were to identify competencies for teaching elementary science and develop appropriate instructional materials and strategies to be used in a pre-service teacher preparation program.

The Project Team began with a general discussion of the roles of the elementary science teacher and derived from that analysis a list of competency areas which included the following:

1. Inquiry Skills and Processes
2. Long and Short-term Planning
3. Teaching Tactics
4. Questioning Techniques
5. Classroom Management Techniques
6. Evaluating Commercial Materials for Science
7. Evaluating

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INSTRUCTIONAL MATERIALS AND STRATEGIES (Cont'd.)

The Project Team was divided into three sub-groups, each of which worked on refining competency statements in a single area and generating ideas for modules which might be used to develop these competencies. Short and long-term planning, classroom management, and teaching tactics were the competency areas selected by the Project Team for consideration during the Winter Semester, 1974. Selection was based primarily on the interests and skills of the public school teachers on the Project Team. University faculty members committed themselves to developing the four remaining competency areas independent of the Project Team effort.

The competency identification effort resulted in an overall rationale, seven goal statements and specific objectives for each competency area. These are listed below.

Rationale:

A basic assumption of the educational enterprise is that what the individual learns in it will be of use to him in his personal, social, and natural environments, now and in the future. The educational institutions must help students to develop content, skills, attitudes, appreciations, and interests that are transferable to other situations and resistant to forgetting.

The science methods class has been designed as a hands-on activity-oriented program. Stress is placed on methods used to generate, organize and evaluate science content. Science is viewed as a process and not as a body of knowledge to be repeated on examinations.

Competency Areas:

1. Process-Inquiry Skills
2. Questioning Techniques
3. Science Equipment and Materials
4. Teaching Tactics

Competency Areas: (Cont'd.)

5. Planning for Teaching
6. Classroom Management
7. Evaluation Techniques

Goals:

1. The student will demonstrate competency in: a) the acquisitions of the process skills and, b) the ability to plan activities for elementary children utilizing each skill.
2. The student will utilize specific questioning techniques.
3. The student will identify and utilize science equipment and curricular materials that can be used to conduct learning activities for elementary children.
4. The student will identify and demonstrate the ability to use selected teaching techniques in conducting learning experiences involving science skills or concepts.
5. The student will demonstrate the ability to make effective short-range and long range plans for science teaching.
6. The student will demonstrate selected classroom management skills.
7. The student will demonstrate his ability to utilize the given evaluation techniques.

Behavioral Objectives:

1.01. Using the direction and materials provided, the student will demonstrate the following scientific process skills by successfully completing at least one activity utilizing each skill:

A. Observing: given a variety of objectives, the student will select one from those provided and list ten observations.

B. Classifying: given a box containing a variety of objects, the student will classify the objects by separating them into various groups and labeling them.

C. Measuring: given different lengths of paper, the student will arrange them in a logical order and utilize them in measuring some object.

D. Using space-time relations: given geometric shapes, the student will construct new shapes utilizing two or more of the given shapes.

E. Communicating: given an object such as a sugar cube, seed, salt, etc. the student will describe it by listing observations before interaction takes place, during the interaction and after the interaction.

F. Predicting: using materials and directions provided, the student will make a prediction and compare it with actual results.

G. Inferring: given a variety of sealed boxes, the student will select three and infer the identity of objects concealed in the boxes.

H. Integrated Processes (e.g., defining, operationally, formulating hypothesis, interpreting data, controlling variables, experimenting): the student will select a question from those provided and design and conduct an experiment to answer the selected question.

Behavioral Objectives: (Cont'd.)

1.02. The student will plan activities for use with elementary children utilizing each of the process skills.

2.01. The student will select a topic in science and formulate questions at each cognitive level indicated by Sanders.

2.02. The student will identify questions as either background-centered or solution-centered.

2.03. The student will give appropriate rationale for his responses.

3.01. The student will examine the following science programs: ESS, SCIS, and SAPA in terms of scope and sequence and perform at least two activities for each.

3.02. The student will identify and utilize basic science equipment for conducting activities that illustrate major science concepts in at least four of the following areas:

- A. Measurement
- B. Molecules and heat energy
- C. Sound energy
- D. Light energy
- E. Magnets and their properties
- F. The energy of electricity
- G. Machines and force
- H. The earth's changing surface
- I. Air and weather
- J. The earth in space
- K. Seeds and plants
- L. Animal groups
- M. Human growth and nutrition

4.01. The student will define and identify the following teaching tactics:

- A. Initiating tactics
- B. Focusing tactics
- C. Extending tactics
- D. Terminating tactics

4.02. The student will select activities and experiments from those suggested and complete the activity as described on an accompanying card.

4.03. The student will incorporate the selected teaching tactics in lesson and unit plans prior to the field experience.

5.01. The student will select a science topic and make a daily lesson plan which includes behavioral objectives, activities to be performed, materials needed and evaluation to be used.

5.02. The student will select a science topic and develop a resource unit that could be used with elementary children.

5.03. The student will examine the state science objectives and write out activities that could be used in helping children to acquire those objectives.

6.01. The student will identify the factors in the physical environment that will influence the child's behavior.

Behavioral Objectives: (Cont'd.)

6.02. The student will describe situations in which the following can best serve the objectives of the lesson:
A. Small group
B. Large group
C. Individual conferences
D. Oral work
E. Written work

6.03. The student will identify alternative solutions to the following problems of the child:
A. Accidents
B. Injury illness
C. Bathroom problems
D. Physical handicaps

6.04. The student will identify alternative procedures for:
A. Routine classroom tasks
B. Behavioral problems
C. Interruptions of classroom routines

7.01. The student will identify and describe the following evaluation techniques:
A. Observation
B. Discussion
C. Questionnaires and inventories
D. Anecdotal records
E. Charts and check lists
F. Work samples
G. Dramatization
H. Logs and diaries
I. Open-ended questions
J. Conferences
K. Teacher made tests
L. Standardized tests

7.02. The student will utilize the given evaluation techniques during the field experience II (small group teaching) portion of the class.

7.03. The student will evaluate the given evaluation techniques.

The total development effort resulted in the following modules:

1. Process-Inquiry Skills
2. Teaching Tactics
3. Questioning Techniques
4. Planning
5. Science Equipment and Materials

Copies of these modules are included in Appendix A.

The Project Team was unable to develop mastery tests or other evaluation strategies for the modules. However Dr. Harris and Dr. Evans, the University faculty members who teach the Science Methods Course developed mastery evaluation techniques during the Revision Phases of the project.

Field Experience I:

In addition to identifying competencies and developing modules for use in the Science Methods Course, the Project Team and a Support Team of seven (7) additional public school teachers planned a brief field experience to occur concurrent with the science methods instruction. Two experiences, an observation and mini-teaching were designed by the Project Team for use during the Initial Tryout of project materials.

INITIAL TRYOUT PERIOD

During the second eight weeks of the Winter Semester, 1974, students in four sections of the Science Methods Course used project materials. Students in two sections used traditional materials and strategies. Dr. Harris and Dr. Evans of the Project Team taught all sections. Sections using project materials were randomly designated with the stipulation that Dr. Harris would teach only experimental sections and Dr. Evans would teach two experimental and two traditional sections.

A modular format was the main instructional feature for the experimental groups. During the Initial Tryout modules contained behavioral objectives, and activities designed to aid the students in reaching the stated objectives. No pre- or posttest had been developed at that time.

The following modules were completed by all students in the experimental sections:

1. Process-Inquiry
2. Questioning
3. Science Materials
4. Teaching Tactics
5. Planning (Resource Unit)

The activities for each module included: attending short lectures given by the instructor, reading selected sections from the textbook, or other source material, working with small groups as well as individually in performing assigned tasks, meeting with the instructor for small group and individual conferences, gathering and recording data and submitting to instructor for approval. If the objectives were not met on the first attempt, the student was allowed to try again using feedback obtained from instructor.

Two field activities were included for the experimental sections. The first one involved spending two hours in observation-participation in a local elementary classroom.

The second field activity required the student to teach a lesson to a small group of children in their assigned classroom. Each student first submitted his lesson plan to the instructor for approval. A student check list was given to each student to help him prepare for the mini-teaching. Included were questions for use in self-evaluation after the mini-lesson. Each participating classroom teacher (members of the Project and Support Teams) was asked to evaluate the student's competency by responding to the questions included on an evaluation sheet provided by the instructor. The following criteria were used in the evaluation:

1. Preparation
   - A. Was the classroom teacher contacted prior to the lesson?
   - B. Did the student confer with the teacher on last minute or unique aspects of the lesson plans?
   - C. Did the student have prepared lesson plans?
   - D. Did the student come prepared to deal with the physical arrangements?
   - E. Was there evidence of prior rehearsal of the lesson?
   - F. Were the needed teaching aids ready for use?
   - G. Did the student dress appropriately?
2. Presentation
   - A. Was the subject matter properly introduced?
   - B. Was the topic appropriate to the grade level?
   - C. Did the student demonstrate knowledge of the topic presented?
   - D. Did the student cover the lesson plans?
   - E. Were the teaching aids, equipment and materials used?
   - F. Was the vocabulary within the understanding of the children?
   - G. Did the questions augment the lesson?
   - H. Were the children sufficiently involved in the lesson?
   - I. Did the student demonstrate poise?

3. Culmination
   A. Closure
      1. Tactics demonstrated
         a. Summarization
         b. Student participation (questions)
         c. Extending comments (open ended)
         d. Stopped lesson
   B. Evaluation
      1. Techniques used
         a. Informal observations
         b. Written worksheet
         c. Data collection
         d. Verbal
         e. Other means and techniques

It was the intent of the original proposal that preparation for and implementation of the mini-lessons during the second field activity would include the development, by University students, of assessment instruments to be used during the pre-and post-mini-teaching to measure appropriate changes in the elementary students taught. Several factors mitigated against this. First, it was impossible to complete the development of an evaluation module to prepare University students to construct such tests. Second, the number of students participating in this experience was expanded from 25 to 100 during the course of the project. Third, time for pre-and-post evaluation of pupils in relation to a single lesson was considered too time consuming and inappropriate by the teachers of the Project and Support Teams in whose classrooms the mini-teaching occurred.

One of the teachers and one of the methods instructors decided to try a different approach to providing methods students additional contact with elementary students. In addition to two field experiences mentioned previously, a second grade class and their teacher were invited to visit and participate in one of the experimental methods classes to give students a chance to apply skills acquired in the methods classes.

INITIAL TRYOUT PERIOD (Cont'd.)

The visit was included as an enrichment activity in the process-inquiry module. In this module, methods students first become skilled in using the specific process skills themselves, then they plan activities for use with elementary children which would help them acquire these skills. In preparation for the visit from the second grade, the methods students divided into small groups and selected one of the skills and an appropriate activity. "Learning centers" were set up and the children were divided into small groups and spent approximately 10 minutes at each center. At the centers the methods students guided the children in an activity designed to aid them in acquiring the specified process skill.

Based on the response of university and elementary school students, it was decided to include at least one of these visits as part of the science methods class in the Fall, 1974 session.

Each student was required to develop a resource unit for use with elementary children. This activity served as the culminating task. The students utilized the knowledge and skills acquired in the previous modules in selecting and organizing objectives, learning experiences, evaluation techniques and instruction materials to develop major scientific understanding of a sizable topic.

REVISION OF MODULES

The Spring Session and Summer Sessions of 1974 were designated as periods of revision. During this time, Dr. Harris collected informal data to be used in the revision. Revision focused on the following: rewriting directions for modules, adding and eliminating learning activities to selected modules; developing student response sheets to be used with the learning activities of each module; writing an introduction to each module; and developing a flow-chart for each module.

INITIAL TRYOUT PERIOD (Cont'd.)

Some revision activities carried over into the early weeks of the Fall Semester, 1974. These were principally involved with evaluating student progress through the modules. Mastery tests were developed and a general student evaluation strategy designed.

In addition to revising existing modules Dr. Harris developed four new modules during the period of revision. Included in this expansion were objectives and constructional activities in the following areas: Textbook Evaluation, Environmental Awareness, Classroom Management, and Metric Measurement.

REVISION TRYOUT AND FOLLOW-UP

During the Fall Semester, 1974, students in five sections of the Science Methods Course were exposed to the revised and expanding competency-based materials of the project. All of the sections were taught by Dr. Harris or Dr. Evans. No traditional sections were studied during this semester.

During this semester the students were required to complete each module. Students worked in small groups in completing the activities assigned. Interaction between students and with the instructor was encouraged. Each student submitted the answer sheets for each module completed and received a grade according to how well he/she met the criteria specified for each module. A score ranging from zero to the maximum points assigned to the individual module was possible. The students were given individual tally sheets so that they could keep up with their accumulated points. If a student received a low score on a completed activity he could repeat a similar one and submit the new results to the instructor. If successful on a later attempt, the student could receive up to one less than the total points possible for the module.

REVISION TRYOUT AND FOLLOW-UP (Cont'd.)

The mastery tests were administered individually. These tests varied in makeup depending upon the purpose of the module. Some were "one-class-day" take-home tests, while others were given during the regularly scheduled class period. Tests were designed so that a student utilized the skills acquired in the module. The test scores were counted as 1/3 of the student's final score for each module and the score obtained on the module activity was counted 2/3.

Students did not participate in any field experiences during this semester. The local school system is saturated with student teachers and students from other education classes. Students only contact with children was during the on-campus visit by local elementary classes.

In addition to the tryout of revised materials, during this period of the project students who participated in the Initial Tryout were involved in Field Experience II, a 15-week directed teaching experience. Several students were observed and interviewed, and their supervising teachers interviewed to create a data base for the construction of a follow-up questionnaire to be completed by supervising teachers of students in the project.

PROJECT EVALUATION INSTRUMENTS

The purposes of project evaluation were to generate and interpret data which could be useful in making summative judgements about project goals. Essentially the project evaluation focused on the following questions:

1. Do students in CBTE science methods classes achieve the objectives of a modularized science methods instruction?
2. Are the achievements of CBTE and non-CBTE students in science methods classes different?
3. Do CBTE science methods classes generate more positive attitudes toward teaching Science-as-process than non-CBTE classes?

4. Do non-CBTE science methods classes generate more positive attitudes toward teaching science as a body of knowledge than CBTE classes?
5. What are student perceptions of instructional support in CBTE classes and how are these different than in non-CBTE classes?
6. Are CBTE students more effective in lesson planning and implementation during their Directed Teaching (Field Experience II) than non-CBTE students?

In addition to these questions directly related to Project goals, the design and implementing of tryouts and data collecting allowed for the investigation of two research questions:

1. Do students with concurrent field experiences differ in achievement, attitudes toward teaching science, and perceptions of achievement support than students who do not have such experience?
2. How reliable and valid are self-reported achievement ratings?

To deal with these questions the following instruments were used in the project.

Self-Rated Achievement Forms 1 and 2:

These instruments required that students rate their achievement of course goals on a five-point scale.

Form 1:

During the Initial Tryout students in CBTE and traditional non-CBTE sections responded to 20 goal statements in terms of the following 5 point scale.

How successful have you been in accomplishing this goal?

1. Unsuccessful
2. Somewhat successful
3. Moderately successful
4. Highly successful
5. Extremely successful.

Self-Rated Achievement Forms 1 and 2: (Cont'd.)

The 20 goal statements of Form 1 are:

1. Understanding what inquiry skills are and how science-as-a-process is different than science-as-a-body-of-knowledge.
2. Being able to plan learning activities for children which emphasize the development of inquiry skills such as observing, classifying, measuring, predicting, and inferring.
3. Being able to evaluate the extent to which a pupil is or is not making progress in developing his inquiry skills.
4. Being able to identify the inquiry skills implied in various curriculum materials, learning activities, or lesson plans.
5. Knowing how to use the following tactics to gain students' attention and to relate a science lesson to their past experiences: using apparent inconsistencies, creating competition, creating a problem, setting expectancies.
6. Knowing how to use the following tactics for creating a common base of experiences related to instructional objectives of a science lesson: laboratory activities, field trips, demonstrations, role playing, quests, simulations.
7. Knowing how to interact with students during a science lesson in a way that will help them become mentally involved with the lesson.
8. Knowing the scope, content, and focus of the major experimentally based and developed programs in elementary science; ESS, S-APA, SCIS.
9. Knowing how to review and summarize a science lesson so that the important points are highlighted and students can be given a chance to demonstrate understanding.
10. Knowing the state minimal performance objectives in science.
11. Being able to incorporate the state minimal objectives in science into plans for science units and lesson plans.
12. Understanding the important role of teacher questions in guiding learning.
13. Being able to distinguish between different kinds of questions: memory, translation, interpretation, application, analysis, synthesis, evaluation.
14. Being able to identify an appropriate topic for a unit of instruction in elementary science.
15. Being able to write instructional objectives for a science unit.
16. Being able to identify useful and needed resources to teach a science unit.
17. Being able to identify ways of evaluating student achievement for an elementary science unit.
18. Knowing how to individualize instruction in science.
19. Developing greater understanding of the basic science concepts taught in elementary programs which deal with weather, space travel, human growth, nutrition, magnets, electrical energy, and the surface of the earth, for example.
20. Developing a sense of confidence in your ability to teach science in the elementary grades.

Self-Rated Achievement Forms 1 and 2: (Cont'd.)

Although direct reliability coefficients for this instrument are not available, correlations of this variable with four other self-report variables measured during the Initial Tryout were available. Since a measure cannot correlate more highly with another measure than it can correlate with itself, the highest intercorrelation may be taken as a lower-bound reliability estimate. For self-rated achievement this value is $r = .78$ for a sample of 120 students randomly selected from those who participated in this phase of the project. As a lower-bound reliability coefficient this value was considered sufficient for using the instrument to evaluate group differences.

Form 2:

In the Revision Tryout students in five CBTE sections responded to 25 goal statements (including revisions of and additions to Form 1 items). A revised five-point scale was also used. Since this instrument is primarily used in the investigation of the second research question identified above and is not directly related to project goals, it is not described here. It may be found as Part II of the Student Opinion Survey in Appendix B.

Perceived Achievement Support, Forms 1 and 2

These instruments required that students rate aspects of the course in terms of the extent to which each aspect contributed to their achievement. Forms 1 and 2 represent different approaches to assessing this variable rather than a preliminary and revised instrument:

Form 1:

During the Initial Tryout this measure included four variables, each of which was rated in terms of its importance as a contribution to the students' achievement of each of the 20 goal statements. The four variables were printed materials used

Perceived Achievement Support, Forms 1 and 2: (Cont'd.)

in the course; interactions with the instructor; interactions with other students; personal effort and individual study. The 20 ratings for each of these variables were made on the following five-point scale:

How much did this contribute to your achievement of this goal?
1. No contribution
2. Somewhat of a contribution
3. Moderately important contribution
4. Highly important contribution
5. Extremely important contribution

Scores on each of the Achievement Support Variables could range from 20 to 100. Lower-bound reliability estimates based on variable intercorrelations for each variable are listed below

Achievement Support	
Printed Materials	.68
Instructor Interaction	.70
Interactions with other Students	.71
Personal Effort	.78

These reliabilities were considered adequate for testing group differences.

Form 2:

In the Revision Tryout students were asked to check those items on a list of 13 "learning activities or aspects of the course" which made "an important or significant contribution" to their accomplishments in the course. This instrument is Part III of the Student Opinion Survey found in Appendix B. The 13 items listed in the instrument are listed below.

1. Having a modular format to provide structure in the course.
2. Having objectives specified and made explicit.
3. Having activity oriented assignments and experiences.
4. Having an opportunity to observe children during a science lesson.
5. Having an opportunity to work with children who visited the class.

Perceived Achievement Support, Forms 1 and 2 (Cont'd.)

6. Using the answer sheets that go with instructional modules.
7. Having assigned readings and texts.
8. Having instructor handouts other than instructional modules.
9. Having formal or lecture type sessions with the instructor.
10. Having informal group meetings with the instructor.
11. Having individual conferences with the instructor.
12. Having opportunities to work with other students and discuss coursework with them.
13. Using the Instructional Materials Center.

Attitudes Toward the Teaching of Science

In the Initial Tryout students were assessed on a 10 concept semantic differential. This measure is found in Appendix B. Each of the 10 concepts was rated on 10 polar adjectives, 5 of which were selected because of their weightings on an "evaluative factor" in previous research. Five of the concepts rated were examples of teaching science as a process, i.e. "Teaching students how to collect data through the use of the five senses." The other five concepts were examples of teaching science as a body of knowledge, i.e., "Teaching students about molecules and heat energy."

Ratings on five "evaluative factor" adjectives were summed for each of the five science-as-process concepts and science-as-knowledge concepts to yield ten attitude scores.

Attitudes Toward Self

In the Revision Tryout students were assessed on two aspects of self-concept using the semantic differential technique. Two concepts rated were: "MYSELF AS A TEACHER" and "MYSELF AS A SCIENCE TEACHER". Each concept was rated on 25 sets of polar adjectives. Five of these were selected for their heavy loadings on an "evaluative factor" in previous research. Ratings for each concept were summed over the five scales to yield two attitude toward self scores. The concepts and scale of this instrument are included as Part IV of the Student Opinion Survey which is found in Appendix B.

Performance Ratings

To assess performance during Field Experience II, supervising teachers completed a checklist rating form which evaluated the students' performance in preparing lesson plans and teaching lessons in science. Sixteen performance criteria were identified for lesson planning and 20 for lesson teaching. These items can be found in the Elementary Education Field Experience Survey found in Appendix B.

SAMPLES

In this project, two populations of approximately 320 students each were sampled to participate in the Initial and Revision Tryouts of CBTE Materials. The populations sampled were CMU elementary education students preparing to student teach in the Fall, 1974 and CMU elementary education students preparing to student teach in the Winter, 1975. It is in the semester just prior to student teaching that CMU elementary education students typically take their Science Methods Course.

The Initial Tryout sample consisted of 120 students, 90 selected from CBTE sections and 30 selected from non-CBTE sections. The 90 CBTE students were selected from more than 150 students in the Initial Tryout who used CBTE Materials. These students were selected to represent differing amounts or levels of concurrent field-related activity. Thirty (30) students were selected from each of the three groups -- 1) students who used CBTE Materials but engaged in no concurrent field activities; 2) students who used CBTE Materials and observed concurrently in an elementary classroom; 3) students who used CBTE Materials, observed, and participated in a mini-teaching experience.

The thirty (30) non-CBTE students were selected from a group of sixty (60) students taught by a traditional approach by one of the instructors who also taught CBTE sections. Since CBTE and non-CBTE students were not selected on a random basis the assumption of comparability of the groups must be examined.

Data on students' majors, minors, and grade point averages at the time of entry into the Teacher Education Program was available for 106 of the 120 students. This data is summarized in Table 1 which shows the grade point distributions and the number of science majors or minors for each group sampled in the Initial Tryout.

TABLE 1: FREQUENCY OF SCIENCE AND NON-SCIENCE MAJORS, AND GRADE POINT DISTRIBUTIONS FOR INITIAL TRYOUT SAMPLES

Groups			Major Minor		G.P.A.			
			Science	Non Science	2.0-2.5	2.5-3.0	3.0-3.5	3.5+
I.	CBTE Materials Only	27	4	23	3	11	7	6
II.	CBTE Obs.	27	8	19	9	4	8	6
III.	CBTE Mini-Teaching	25	5	20	6	5	12	2
IV.	Traditional	27	4	23	7	9	8	3
		$X_3^2=2.488$				$X_9^2=2.103$		

A chi-square analysis comparing the frequency of Science and non-Science Majors or Minors in the four comparisons groups of the Initial Tryout resulted in a $X^2=2.488$. This value is not large to warrant rejection of the assumption that the groups were comparable with respect to their science vs. non science academic background.

A chi-square analysis comparing the grade point distributions of students in the four groups yielded a $X^2=2.103$. This value is not large enough to warrant rejection of the assumption that the groups were comparable with respect to academic achievement levels as represented by grade point average.

The Revision Tryout Sample consisted of 79 students selected from 130 students who used the revised CBTE Materials during the Fall, 1974. This sample was used to evaluate the revised modules and to examine the validity of self-rated achievement. The sample consisted of students for whom there was complete data on each of the following variables: a) 25 self-ratings of achievement, b) cumulative grade point average, c) cumulative semester hours in science courses, d) achievement score in the science methods course, e) attitude toward self-as-teacher and self-as-science-teacher scores. Since the validity study involved factor analysis of the variables, complete data was used as the criterion for selecting this sample.

DESIGN

The project design involved a complex interweaving of development, evaluation, and research procedures. Development procedures were summarized in an earlier section of this chapter and described in terms of four phases: Development, Initial Tryout, Revision, and Revision Tryout. In this section, an attempt is made to describe the intertwining evaluation and research aspects of the project and to show the relationship of data collection instruments to each evaluation and research problem.

It is possible to group evaluation and research problems into the following categories: a) description of the intended and incidental outcomes of competency-based instruction in Science Methods; b) comparative analysis of the effects of different levels of concurrent field experience in a competency-based course; and d) the validity of self-rated achievement in assessing the effects of CBTE.

The first two problems may be considered the primary evaluation aspects of the project in that they relate directly to project goals. Problems c and d, however, are research problems only indirectly related to specific project goals, but involving some general research interest. Figure 1 is an attempt to describe the use of assessment instruments in relation to each of these four problem areas.

Problem Areas

Project Measures	A	B.	C	D
Initial Tryout Sample (N=120)				
Self-Rated Achievement, Form 1	X	X	X	
Perceptions of Achievement Support, Form 1	X	X	X	
Attitude Toward Science-As-Process	X	X	X	
Attitude Toward Science-As-Knowledge	X	X	X	
Follow-up Sample (N=85)	X	X	X	
Lesson Planning Performance Ratings	X	X	X	
Teaching Performance Ratings	X	X	X	
Revision Sample (N=79)				
Self-Rated Achievement, Form 2	X			X
Perceptions of Achievement Support, Form 2	X			
Attitude Toward Self-As Teacher	X			X
Attitude Toward Self-As-Science-Teacher	X			X
Course Achievement				X
Background variables (G.P.A. and no. of science courses)				X

Figure 1 - Schematic Representation of Project Measures Involved in Different Problem Areas.

SUMMARY

The procedures used in this project comprise a complex interweaving of development, evaluation and research methods. Twelve specific measures were used in various phases of an initial tryout, a directed-teaching follow-up, a revision tryout, and a validity study. Project measures were used to investigate two related research problems as well as to answer the primary evaluation questions.

IV
DATA AND ANALYSES

Project data were collected and analyzed to solve four major problems: a) To what extent did CBTE Materials have the desired effects on the achievement, attitudes and performance of students in a University Science Methods Course and what were students' perceptions of instruction in the CBTE program? b) To what extent were were the achievement, attitudes, performance, and perceptions of CBTE students different from those of non-CBTE students? c) To what were the achievement, attitudes, performance, and perceptions of CBTE students who have concurrent field experiences different from those of CBTE students who do not have concurrent field experiences? d) How valid are self-ratings of achievement as an assessment measure in a CBTE program? Data relevant to each of these problems are reported separately.

CBTE SCIENCE METHODS OUTCOMES

Competency statements identified in the project and the modules designed to develop these competencies were tested with two groups of students.

A sample of 90 students selected from five sections of students who use the CBTE Materials during an Initial Tryout in the Winter, 1974 were assessed on the following project measures at the completion of the Science Modules: Self-Ratings of Achievement, Form 1; Perceptions of Achievement Support, Form 1; and Attitudes Toward Science-As-Process and Science-As-Knowledge. In addition, a subsample of this group was observed during the following semester as they participated in directed teaching experiences. Performance ratings in two areas were made by supervising teachers, i.e., lesson planning and lesson implementation.

CBTE SCIENCE METHODS OUTCOMES (Cont'd.)

In the Fall, 1974 students in 5 sections of the Science Methods Course used revised CBTE Materials. These students were administered the following project measures upon completion of the science modules: Self-Rated Achievement, Form 2; and Attitudes Toward Self-As-A-Teacher and Self-As-Science-Teacher.

Assessment data for each of these measures is presented to describe the achievement, attitudes, instruction-related perceptions, and performance of University students in a CBTE program.

Achievement

Achievement was assessed by self-report. Students rated their achievement of course goals on a five-point scale. In the Initial Tryout, 20 course goals related to competency areas were listed. For the Revision Tryout, 25 goal statements were used in the ratings.

Table 3 lists the 20 goals assessed in the Initial Tryout and shows the mean, standard deviation, and percent of sample whose ratings were considered to reflect less than satisfactory achievement, i.e., ratings of "1" or "Unsuccessful."

The data in Table 3 show three goal statements for which the mean rating is less than "3" or "Moderately Successful" achievement -- goals 3, 10, 11, with areas of 2.97, 2.04, 2.19. Additionally, for goals 17 and 18 the percent of students whose achievement is less than satisfactory is 12.2 and 11.1 respectively.

TABLE 3: MEAN SELF-RATED ACHIEVEMENT ON 20 INITIAL TRYOUT GOAL STATEMENTS FOR CBTE STUDENTS (N=90)

Goal Statement	Mean	Std. Dev.	%Unsatisfactory
1. Understanding what inquiry skills are and how science-as-a-process is different than science-as-a-body-of-knowledge.	3.77	.786	0.0
2. Being able to plan learning activities for children which emphasize the development of inquiry skills such as observing, classifying, measuring, predicting, and inferring.	3.87	.802	0.0
3. Being able to evaluate the extent to which a pupil is or is not making progress in developing his inquiry skills.	2.97	.911	5.6
4. Being able to identify the inquiry skills implied in various curriculum materials, learning activities, or lesson plans.	3.69	.852	0.0
5. Knowing how to use the following tactics to gain students' attention and to relate a science lesson to their past experiences: using apparent inconsistencies, creating competition, creating a problem, setting expectancies.	3.63	.872	1.1
6. Knowing how to use the following tactics for creating a common base of experiences related to instructional objectives of a science lesson: laboratory activities, field trips, demonstrations, role playing, quests, simulations.	3.73	.850	0.0
7. Knowing how to interact with students during a science lesson in a way that will help them become mentally involved with the lesson.	3.52	1.017	4.4
8. Knowing the scope, content, and focus of the major experimentally based and developed programs in elementary science: ESS, S-APA, SCIS.	3.60	1.023	4.4

TABLE 3: (Cont'd.)

Goal Statement	Mean	Std. Dev.	%Unsatisfactory
9. Knowing how to review and summarize a science lesson so that the important points are highlighted and students can be given a chance to demonstrate their understanding.	3.14	.989	6.7
10. Knowing the state minimal performance objectives in science.	2.04	1.133	44.4
11. Being able to incorporate the state minimal objectives in science into plans for science units and lesson plans.	2.19	1.287	43.3
12. Understanding the important role of teacher questions in guiding learning.	3.77	.974	2.2
13. Being able to distinguish between different kinds of questions: memory, translation, interpretation, application, analysis, snythesis, evaluation.	3.29	.992	3.3
14. Being able to identify an appropriate topic for a unit of instruction in elementary science.	3.40	1.055	6.7
15. Being able to write instructional objectives for a science unit.	3.32	1.185	8.9
16. Being able to identify useful and needed resources to teach a science unit.	3.68	.949	3.3
17. Being able to identify ways of evaluating student achievement for an elementary science unit.	3.14	1.066	12.2
18. Knowing how to individualize instruction in science.	3.14	1.108	11.1
19. Developing greater understanding of the basic science concepts taught in elementary programs which deal with weather, space travel, human growth, nutrition, magnets, electrical energy, and the surface of the earth, for example.	3.37	1.127	7.7
20. Developing a sense of confidence in your ability to teach science in the elementary grades.	3.62	.942	3.3

Achievement (Cont'd.)

Examination of these five goal statements pinpoints several weaknesses in the CBTE effort in science as it was implemented during the Initial Tryout.

Goal statements 3 and 17 relate to competence in evaluating learner behavior and achievement. The module for this competency was not developed in time for use during the Initial Tryout. Other modules apparently cannot substitute for an evaluation module.

Goal statements 10 and 11 relate to competence in using "Michigan Minimal Performance Objectives in Science." During the Initial Tryout students used the minimal performance objectives in developing competence in lesson planning and preparing lessons for mini-teaching activities. These data suggest that minimal performance objectives must be approached more directly in the modules.

Goal statement 18 related to the ability to individualize instruction in science was not the focus of any single module. It was less than satisfactorily developed through the indirect means of offering instruction in a modularized format.

The data of the Initial Tryout show that, for 75 percent of the goals, students' self-reported achievement is at satisfactory levels.

Students participating in the Revision Tryout rated 25 goal statements on a revised five-point scale. On the revised scale ratings of 3-5 were considered satisfactory levels of achievement and ratings 1 and 2 were considered less than satisfactory. Table 4 shows the mean, standard deviation, and percent of students achieving at less than satisfactory levels for ratings of each goal statement.

TABLE 4: MEAN SELF-RATED ACHIEVEMENT ON REVISION TRYOUT GOAL STATEMENTS FOR CBTE STUDENTS (N=79)

Goal Statement	Mean	Std. Dev.	%Unsatisfactory
1. Understanding what inquiry skills are and how science-as-a-process is different than science-as-a-body-of-knowledge.	4.01	.650	00
2. Knowing how to use the following inquiry skills: observing, classifying, measuring, using space-time relations, communicating, predicting, inferring.	4.24	.582	00
3. Being able to plan learning activities for children which emphasize the development of inquiry skills such as observing, classifying, measuring, predicting, and inferring.	3.92	.730	01
4. Knowing how to use the following tactics to gain students' attention and to relate a science lesson to their past experiences: using apparent inconsistencies, creating competition, creating a problem, setting expectancies.	3.70	.705	03
5. Knowing how to use the following tactics for creating a common base of experiences related to instructional objectives of a science lesson: laboratory activities, field trips, demonstrations, role playing, quests, simulations.	3.77	.733	03
6. Knowing how to use tactics which encourage pupils to form a new concept, principle, or skill or apply a concept, principle, or skill in a new situation.	3.52	.617	01
7. Knowing how to review and summarize a science lesson so that the important points are highlighted and students can be given a chance to demonstrate their understanding.	3.80	.687	04
8. Understanding the important role of teacher questions in guiding learning.	4.27	.655	00

TABLE 4: (Cont'd.)

Goal Statement	Mean	Std. Dev.	%Unsatisfactory
9. Being able to distinguish between different kinds of questions: memory, translation, interpretation, application, analysis, synthesis, evaluation.	3.42	.826	13
10. Being able to ask questions about science topics which would encourage students to use the following intellectual skills: translation, interpretation, application, analysis, synthesis, evaluation.	3.37	.754	11
11. Knowing the scope, sequence, and focus of the major experimentally based and developed programs of elementary science: ESS, S-APA, SCIS.	3.84	.854	04
12. Being able to analyze and evaluate ESS, S-APA, SCIS.	3.86	.780	04
13. Being able to identify an appropriate topic for a unit of instruction in elementary science.	3.82	.859	06
14. Being able to write instructional objectives for a science unit.	3.71	.879	08
15. Being able to identify useful and needed resources to teach a science unit.	3.81	.752	04
16. Being able to identify ways of evaluating student achievement for an elementary science unit.	3.48	.959	10
17. Knowing the State minimal performance objectives in science.	2.19	1.122	62
18. Being able to incorporate the State minimal objectives in science into plans for science units and lesson plans.	2.30	1.213	60
19. Knowing how to review and evaluate a textbook series in science.	4.08	.859	03

TABLE 4: (Cont'd.)

Goal Statement	Mean	Std. Dev.	%Unsatisfactory
20. Being able to identify or generate content objectives, inquiry skill objectives, psychomotor objectives, and affective objectives involved in short-term teaching strategies.	3.70	.979	09
21. Being able to select and generate appropriate initiating, focusing, extending, and terminating tactics for a short-term teaching strategy in science.	3.76	.734	05
22. Being able to recognize student behaviors which indicate that content objectives, inquiry skills objectives, psychomotor objectives and affective objectives have been achieved.	3.67	.858	06
23. Being able to identify and use environmental awareness activities and strategies which promote environmental problem-solving.	3.56	1.035	10
24. Being able to generate ideas for and construct manipulative teaching aids related to science.	3.89	.862	05
25. Developing a sense of confidence in your ability to teach science in the elementary grades.	3.91	1.052	04

The data of Table 4 show two goals with average levels of achievement below the minimally acceptable level, i.e., goals 17 and 18 relating to State minimal performance objectives in science. In addition, it shows these objectives to be insufficiently mastered by 62 and 60 percent, respectively, of the students in the Revision Tryout Sample. Two other goals have rates of unsatisfactory performance greater than 10 percent. Goals 9 and 10, relating to question-asking skills, were not attained successfully by 13 and 11 percents of the sample respectively.

Perceptions of Achievement Support

During the Initial Tryout CBTE students rated four aspects of the course in terms of how much they contributed to accomplishment of each goal. Ratings were made on a five-point scale. Consequently each of the sources of achievement support received a score which could range between 20 and 100. Table 5 shows the means and standard deviations of each achievement support variables.

TABLE 5: MEANS AND STANDARD DEVIATIONS OF STUDENT PERCEPTIONS OF THE IMPORTANCE OF PRINTED MATERIALS, INSTRUCTOR INTERACTIONS, INSTRUCTOR INDEPENDENT ACTIVITIES, AND PERSONAL EFFORT IN A MODULARIZED COURSE (N=90)

Achievement Support Variable	Mean	Std. Deviation
Printed Materials	63.87	16.025
Interactions with Instructor	61.79	16.296
Instructor Independent Activities	67.06	14.009
Personal Effort	72.71	11.488

The data of Table 5 show that during the Initial Tryout students believed that their own personal effort was the most significant factor in their achievement followed by instructor independent activities and interactions with other students. Printed materials and interactions with the instructor were viewed as less important in contributing to student achievement.

Perceptions of Achievement Support (Cont'd.)

The goals of the CBTE Science project of fostering of independent learning and emphasizing inquiry-based, activity oriented instruction seem to have been achieved, based on the ratings of achievement support variables during the Initial Tryout. In the modularized approach, the importance of printed materials and interactions with instructor seem to play a less important role.

During the Revision Tryout, student perceptions of the relative importance of various aspects of instruction were assessed in a different format. Thirteen aspects of the course were listed and students were asked to check and rank those which made an important or significant contribution to accomplishments in the course. Data from 77 students was used. Each item was weighted according to the rank given it by the student with ranks of 1 to 10 contributing to the weighted score. Items ranked 1 were given values of 10, items ranked 2 a value of 9, items ranked 3 a value of 8, and so forth. Total weights for each item were calculated by summing over all students.

Table 6 lists each of the 13 items and the total weight given it by the 77 students, with each weight expressed as a percent of the highest weighted item. Items were listed in order of perceived importance.

The data of Table 6 are consistent with the perceptions of instructional support of achievement identified in the Initial Tryout. Having opportunities to work with other students and having activity-oriented assignments were given more than 5 times the weight of having formal or lecture-type interactions with the instructor. Students in the Revision Tryout sample perceived the modularized, instructor-independent, activity-oriented assignments as the most significant factors in their achievement.

TABLE 6: RELATIVE WEIGHTS GIVEN TO THIRTEEN FACTORS AS MAKING SIGNIFICANT CONTRIBUTIONS TO ACHIEVEMENT IN THE CBTE SECTIONS OF THE SCIENCE METHODS COURSE (N=77)

Factors	Weight
Having opportunities to work with other students and discuss course work with them	100
Having activity-oriented assignments and experiences	97
Having a modular format to provide structure in the course	82
Having an opportunity to work with children who visited the class	74
Having objectives specified and made explicit	61
Using the Instructional Materials Center	51
Having informal group meetings with the instructor	49
Having individual conferences with the instructor	40
Having assigned reading and texts	37
Having an opportunity to observe children during a science lesson	36
Using answer sheets that go with instructional modules	33
Having instructor handouts other than modules	19
Having formal or lecture type sessions with the instructor	17

Attitudes Toward Teaching Science

Semantic differential measures of attitudes towards teaching 10 science objectives were assessed prior to and following instruction. Five of the attitudes involved the ratings of teaching possess objectives and the other five used ratings of teaching knowledge objectives. Pre and posttest measures were not taken on matched groups; however, it seems reasonable to assume that each sample is an independent representative sample of the population of students at two different points in time. The t-distribution was used to evaluate mean differences between the two samples on each teaching objective rated.

Table 7 shows the concepts (i.e. teaching objectives), pre- and post-instruction means, standard deviations, and the t-value of each comparison. One of ten comparisons, resulted in a significant difference from pre- to posttest ($t=3.23$, $p. < .01$). Students attitudes toward teaching pupils "to believe in science as a means of dealing with real problems" increased during instruction. No other differences were significant.

Attitudes Toward Self As Teacher

In the Revision Tryout, students responded to semantic differential means of two concepts "MYSELF AS A TEACHER" and "MYSELF AS A SCIENCE TEACHER". A five item, 7-point scale was used to rate each concept. Scores could vary between 7 and 35. The t-test for related measures was used to compare these two dimensions of the self-concept of students preparing to teach,

Table 8 shows means, standard deviations, and t-values for the comparison. The comparison.shows students to have a significantly more positive view of themselves as teachers in general than they do of themselves as teachers of science ($t=3.689$, $p. < .01$),

TABLE 7: PRE- AND POSTTEST MEANS, STANDARD DEVIATION, AND t-VALUES OF MEASURES OF ATTITUDES TOWARD TEACHING SCIENCE-AS-PROCESS AND MEASURES OF ATTITUDES TOWARD TEACHING SCIENCE-AS-KNOWLEDGE.

Concepts[a]	Pretest (N-141)	Posttest (N=90)	t
Teaching students to:			
1. Believe in science as a means of dealing with real problems.	29.26[b] (5.52)[c]	31.30 (3.61)	3.12**
2. Interpret a table of data.	30.29 (6.10)	30.53 (4.44)	0.32
3. Be willing to subject data and opinions of the criticism of others.	30.42 (5.56)	31.47 (3.71)	1.591
4. Collect data using the five senses.	32.55 (4.72)	33.59 (2.27)	1.96
5. Seek clarification of another's point of view.	32.26 (2.91)	31.43 (3.77)	-1.89
Teaching students about:			
6. Molecules and heat energy	27.93 (4.80)	28.78 (4.12)	1.43
7. Space	30.28 (3.97)	30.43 (3.07)	0.51
8. Earth's changing surface	30.33 (4.23)	30.59 (3.93)	0.47
9. Light energy	29.26 (4.66)	29.08 (4.40)	-0.23
10. Seeds and plants	31.84 (3.29)	31.58 (3.67)	-0.56

a Concepts are divided into process category (1-5) and knowledge category (6-10).
b Total possible score was 35.
c Scores in parentheses are standard deviations.
** $< .01$ for a two-tailed test.

TABLE 8: MEANS, STANDARD DEVIATIONS AND t-VALUE FOR COMPARING MYSELF-AS-TEACHER TO MYSELF-AS-SCIENCE-TEACHER. (N 79)

Concept	Mean	Std. Dev.	t-Value
AS TEACHER	29.95	3.980	3.689**
AS SCIENCE TEACHER	27.72	4.249	

**p. L.001 for two-tailed test

Performance Ratings

The students who were the sample for the Initial Tryout were rated by their supervising teachers during a directed teaching experience during the semester immediately following their CBTE Science Methods Course. Ratings in the form of check-listed items were made for 16 performance factors related to lesson planning and 20 performance factors related to lesson implementation. Supervising teachers were instructed to rate students' performance specifically with reference to science and/or also with respect to other curriculum areas in general.

For the sample of 90 CBTE students, 71 were listed as having directed teaching placements during the semester following their science methods course. For this subsample 35 follow-up questionaires were returned by supervising teachers, representing a return rate of just over 50 percent. The data on the completed questionaires is summarized in Tables 9 and 10. Table 9 lists each lesson planning performance, item, shows the percentage of the sample rated positively on the item in reference to science, and the percentage rated positively in reference to other curriculum areas.

TABLE 9: SUMMARY OF PERFORMANCE RATINGS IN PLANNING INSTRUCTION DURING DIRECTED TEACHING FOR STUDENTS IN CBTE SCIENCE METHODS SECTIONS (N-35)

Lesson Planning Factors	Percent Successful	
	Science (N-18)	Other (N-33)
1. Learning outcomes stated clearly	83	73
2. Learning outcomes appropriate for pupils	94	88
3. Achievement indicators identified	67	73
4. Measures of achievement identified	67	85
5. Contains provisions to modify plan to meet individual needs	83	67
6. Instructional materials clearly identified	94	85
7. Instructional materials appropriate to learners and lesson objectives	94	88
8. Organizational procedures identified	83	73
9. Organizational procedures appropriate to learners and objective	78	82
10. Contains provision for pre-lesson assessments	56	42
11. Makes provision for feedback to pupils during lesson	83	73
12. Makes provision for post-lesson assessments	56	61
13. Indicates what happens next if objectives are achieved	44	42
14. Indicates what happens next if objectives are not achieved	50	36
15. Plan appropriate to school setting	94	94
16. Plan feasible given background skills of student teachers	94	88

a Percents are used because different numbers of students were rated in science and other curriculum areas in general. Only slighdy more than half of the supervising teachers were able to rate student lesson plans in science; while all but two students were rated in other areas.

TABLE 10: SUMMARY OF PERFORMANCE RATINGS IN IMPLEMENTING INSTRUCTION DURING DIRECTED TEACHING FOR STUDENTS IN CBTE SCIENCE METHODS SECTIONS (N35)

Teaching Performance Factor	Percent Successful	
	Science	Other (N=31)
1. Learning objectives explained to pupils	78	74
2. Looked for evidence of understanding objectives	83	94
3. Attempted to help pupils view objectives as worthwhile	78	87
4. Referred back to objectives during lesson	61	65
5. Modified lesson in response to student needs as they appeared.	89	90
6. Managed unexpected visitors	72	84
7. Managed mildly disruptive pupils to prevent "ripple-effect"	83	68
8. Managed pupil disruptions in a way to discourage their repetition	61	71
9. Used formal or informal pre-lesson assessment	83	77
10. Pre-lesson assessment brief and without drawing undue attention to it.	83	68
11. Used pre-lesson information to modify instruction	94	74
12. Transition between lesson and previous activities was smooth	94	90
13. Used intrisically interested activities and kept interest during lesson	89	94
14. Used questioning strategies to get pupil interaction started	100	97
15. Used concrete rewards or tokens to motivate pupils	39	55
16. Materials used to best advantage	100	97
17. Instructional procedures used to best advantage	94	94
18. Pupil grouping appropriate and effective	83	81
19. Lesson terminated effectively	83	84
20. Effective records of pupil achievement maintain'	61	55

Performance Ratings (Cont'd.)

Table 9 shows a high degree of consistency in the ratings of successful performance between science lesson planning and lesson planning in the other areas of the curriculum. The four lowest rated items were the same regardless of curriculum area, i.e., Items 10, 12, 13 and 14. These items related to two areas of concern -- evaluating learner performance and developing continuity between lessons. Less than 60 percent of the students rated were successful in these areas.

Overall student success in lesson planning was higher in science, 76.25%, than it was in other curriculum areas, 71.88%.

Table 10 summarizes the performance ratings for teaching performance during lessons in science and other curriculum areas in general. These data show low rates of success on three teaching performance items for ratings relating to both science and non-science lessons--Items 4, 15, and 20. Two of these items deal with performance factors which many supervising teachers noted were not necessary in the contexts in which the student teacher was being evaluated. Using concrete rewards and tokens was unnecessary because of the success of the student teachers in appealing to the interests of students by presenting intrinsically motivating tasks. Providing a way of keeping a record of pupil achievements was accomplished in many instances by adopting the system of the supervising teacher.

In teaching both science and non-science lessons, CBTE pupils were not generally successful (61 and 65%) in referring back to the objectives of the lesson.

In addition to the consistently low ratings, CBTE pupils were rated relatively low (61%) in managing pupil disruptions in a way to discourage their repetition during science teaching. Keeping pre-lesson assessment brief was rated relatively low (63% during non-science teaching).

Performance Ratings (Cont'd.)

Averaging performance ratings over all 20 factors, students' success rates were 80.40 for teaching science lessons and 79.95 for teaching non-science lessons.

Summary

The outcomes of the CBTE science methods course may be summarized as follows:

1. During the Initial and Revision Tryouts the achievement of CBTE students of goals relating to knowing and using State Minimal performance objectives was below mastery for 44 and 61 percents of the students involved.

2. During the Initial Tryout 10% or more of the students performed below mastery levels on goals relating to the ability to evaluate pupil learning and achievement and the ability to individualize pupil learning. During the Revision Tryout 90% of the students showed mastery of goals relating to evaluating pupil learning. The goal of teaching students to individualize instruction was dropped during the Revision Tryout.

3. During the Initial and Revision Tryouts measures of student perceptions of various aspects of instruction showed that students believed they received the most instructional support from instructor-independent, activity - oriented assignments which required their own personal effort to accomplish. Printed materials and formal meetings with the instructor were viewed as least helpful.

4. Attitudes toward teaching science-as-process and science-as-knowledge did not generally change significantly during the course. One of ten, attitude toward teaching measures, showed significantly positive change.

5. Investigation of two self-concept measures, i.e., MYSELF AS A TEACHER AND MYSELF AS A SCIENCE TEACHER showed that CBTE instructed students were significantly more positive toward themselves as teachers in general than as teachers in science.

6. The directed teaching performance of CBTE students in planning and implementing lessons was consistent in science and non-science areas of the curriculum. Relative weaknesses of the students were in planning evaluation procedures, planning continuity from lesson to lesson, and referring back to objectives during teaching.

7. Generally Field Experience II success rates were higher in science than non-science areas and higher for teaching lessons than for planning lessons (Planning: Science - 76.3, Other - 71.9; Teaching: Science - 80.4, Other - 80.0).

COMPARATIVE EVALUATION OF CBTE AND NON-CBTE STUDENTS

The design of this project allowed for the comparison of comparable groups of CBTE and non-CBTE science students. The CBTE group was constructed to represent three levels of concurrent field experience. In other words, four groups of 30 students were studied on selected variables -- three CBTE groups and a non-CBTE group. The single factor analysis of variance was used with pre-planned contrasts between CBTE and non-CBTE pupils on each of 18 dependent variable measures taken during the Initial Tryout and Field Experience II Follow-up.

Achievement and Achievement Support Variables

Self-rated achievement and four achievement-related variables were assessed at the end of the Initial Tryout period. The achievement related variables were perceptions of the importance of printed materials, the instructor, instructor independent activities, and personal effort. Table 11 shows CBTE and non-CBTE means, variance estimates due to treatment groups and error, and F-values for each contrast.

Table 11 shows that the mean differences of the contrasts of three of these five variables are significant at $p < .05$. Mean achievement of CBTE students is 67.144, greater than that of non-CBTE students which is 62.567. CBTE students rated instructor independent activities, 67.07, and personal effort, 72.71, significantly higher as sources of support for their achievements than did non-CBTE students whose ratings were 45.20 and 61.27 respectively.

No differences were observed between the two groups for printed materials and the instructor as a source of support.

Attitudes Toward Teaching Science Objectives

Scores on ten semantic differential measures of attitudes towards teaching specific science process and knowledge objectives were contrasted for CBTE and non-CBTE students. Table 12 shows means, standard deviations, and F-values for the

TABLE 11: MEANS, VARIANCE ESTIMATES, AND F-VALUES FOR ANOVA CONTRASTS (CBTE VS. NON-CBTE) ON FIVE ACHIEVEMENT RELATED VARIABLES.

Variable	Group	N	Mean	Source	d.F.	Variance Estimate	F
Achievement	CBTE	90	67.144	Groups	1	471.502	3.95*
	NON	30	62.567	Error	116	119.424	
Achievement Support:							
Printed Materials	CBTE	90	63.09	Groups	1	95.070	0.43
	NON	30	61.03	Error	116	220.639	
Instructor	CBTE	90	61.79	Groups	1	380.276	1.58
	NON	30	65.90	Error	116	240.235	
Independent Activities	CBTE	90	67.07	Groups	1	10758.367	50.79**
	NON	30	45.20	Error	116	211.826	
Personal Effort	CBTE	90	72.71	Groups	1	2946.922	21.321**
	NON	30	61.27	Error	116	138.218	

* $P < .05$
** $P < .01$

groups in each of these contrasts. In no case is the difference between means significant and it must be concluded that the differences observed are a function of sampling variation. The fact that mean differences favored the CBTE on five comparisons, the non-CBTE group on four comparisons, and were not different at all on the other comparison, provides additional support for this conclusion. In other words, the data provides no basis for distinguishing between CBTE and non-CBTE students attitudes at the end of the science methods course.

Performance Ratings

During a directed teaching follow-up, 50 students in CBTE and non-CBTE science methods sections were rated on their planning of lessons and their actual teaching in science and in other curriculum areas. A high degree of correspondence existed between ratings of lesson plans and teaching in science and other curriculum areas. Since there was more usable data for the ratings in other curriculum areas, scores based on these ratings were used in the analysis. Two subtotals (Planning and Teaching) and a total Performance score were analyzed using a single-factor analysis of variance.

Table 13 shows the means, variances and ANOVA Summaries for each performance rating area and the total. Although the mean ratings of CBTE student teachers were higher than the mean ratings of non-CBTE student teachers in each case, the differences are not statistically significant. There is no basis in the data for concluding that CBTE and non-CBTE students have differential performance levels in lesson planning and lesson performance exhibited during directed teaching. It must be remembered that samples involved in these comparisons are suspect since the rate of return of ratings was about 50 percent of those solicited.

TABLE 12: CBTE AND NON-CBTE STUDENTS MEANS AND F-VALUES FOR MEASURES OF ATTITUDES TOWARD TEACHING SCIENCE AS PROCESS AND AS KNOWLEDGE

Measure	Group	N	Mean	Std. Dev.	F
Process Objectives					
1. Believe in science as a means of dealing with real problems	CBTE	90	31.30	3.61	0.00
	Non-CBTE	30	31.30	3.50	
2. Interpret a table of data	CBTE	90	30.52	4.44	0.056
	Non-CBTE	30	30.73	3.43	
3. Be willing to subject data and opinions to criticism	CBTE	90	31.47	3.71	0.393
	Non-CBTE	30	31.00	3.05	
4. Collect data using five senses	CBTE	90	33.59	2.27	2.25
	Non-CBTE	30	32.87	2.30=	
5. Seek clarification of another's point of view	CBTE	90	31.43	3.77	0.744
	Non-CBTE	30	32.07	2.61	
Knowledge Objectives					
6. Molecules and heat energy	CBTE	90	28.98	4.12	2.499
	Non-CBTE	30	27.57	4.56	
7. Space	CBTE	90	30.43	3.87	0.814
	Non-CBTE	30	29.10	3.75	
8. The Earth's changing surface	CBTE	90	30.59	3.93	0.348
	Non-CBTE	30	31.07	3.65	
9. Light energy	CBTE	90	29.08	4.40	0.154
	Non-CBTE	30	28.66	6.81	
10. Seeds and plants	CBTE	90	31.58	3.67	0.018
	Non-CBTE	30	31.71	6.53	

TABLE 13: MEANS VARIANCE ESTIMATES AND F-VALUES FOR COMPARISONS OF CBTE AND NON-CBTE STUDENT TEACHERS ON LESSON PLANNING PERFORMANCE, LESSON TEACHING, AND TOTAL PERFORMANCE

Variable	Group	N	Mean	ANOVA Source	dF	M.S.	F-Value
Lesson Planning	CBTE	31	11.94	Groups	1	10.989	.639
	Non-CBTE	13	10.85	Error	41	17.185	
Lesson Teaching	CBTE	30	15.90	Groups	1	41.178	2.683
	Non-CBTE	13	13.77	Error	40	15.375	
Total Performance	CBTE	30	28.77	Groups	1	120.987	3.019
	Non-CBTE	13	24.62	Error	40	40.072	

Summary of CBTE Vs. Non-CBTE Students

Comparisons of CBTE and non-CBTE students in science methods sections showed the two groups differed significantly on three self-report measures taken at the end of the science methods course -- measures of self-rated achievement and perceptions of the importance of instructor independent activities and personal effort in supporting course-related achievement.

Perceptions of instructor interactions and printed materials as source of support did not differ significantly for the two groups. Nor were significant differences observed on any of ten attitude measures taken at the end of the course.

Ratings of performance in planning and executing lessons during a directed teaching experience failed to differentiate between CBTE and non-CBTE pupils.

COMPARATIVE ASSESSMENT OF CONCURRENT FIELD EXPERIENCES

Students within the CBTE sections of the Science Methods course were sampled so as to represent different levels of concurrent field experience. Two groups of students observed in local elementary classrooms and/or had the opportunity to participate in a mini-teaching experience with the children in these classrooms. Measures of 15 variables taken at the end of the science methods course and three performance ratings made by the supervising teachers of these students during a second field experience were analyzed using a single-factor analysis of variance.

Achievement and Achievement Support Variables

Self-rated achievement and four achievement-related variables were assessed at the end of the Initial Tryout period. Table 14 shows the means, variance estimates due to treatment groups and sampling error, and F-values for contrasts comparing students participating in one or the other type of concurrent field experience to those students who used CBTE materials but had no concurrent field experience.

The means in Table 14 show that, for each of the variables, the students who participated in no concurrent field experiences had higher scores than students who participated in one of the observation or mini-teaching experiences. These differences are not statistically significant, however, and must be attributed to sampling variation. Field experience during science methods course work does not seem to be related to differential levels of achievement or different perceptions of the learning experience.

Attitudes Toward Teaching Science Objectives

The means and standard deviations for students in each CBTE group on 10 semantic differential measures of attitudes toward teaching specific process and knowledge objectives were calculated.

TABLE 14: MEANS, VARIANCE ESTIMATES, AND F-VALUES FOR ANOVA CONTRASTS (FIELD EXPERIENCE VS. CBTE MATERIALS ONLY) ON FIVE ACHIEVEMENT-RELATED VARIABLES

Variable	Group	N	Mean	Source	d. F.	Variance Estimate	F
Achievement	FIELD	60	66.22	Groups	1	154.941	1.297
	MAT.	30	69.00	Error	116	119.424	
Importance of Printed Materials	FIELD	60	61.62	Groups	1	390.136	1.768
	MAT.	30	66.03	Error	116	220.639	
Importance of Instructor Interactions	FIELD	60	59.63	Groups	1	836.352	3.516
	MAT.	30	66.10	Error	116	240.235	
Importance of Independent Activities	FIELD	60	65.68	Groups	1	344.450	1.626
	MAT.	30	69.83	Error	116	211.826	
Importance of Personal Effort	FIELD	60	71.33	Groups	1	341.683	2.472
	MAT.	30	75.47	Error	116	138,218	

[a]Critical value of F at d=.05 is 3.94.

Attitudes Toward Teaching Science Objectives (Cont'd.)

Table 15 shows the means and standard deviations for each CBTE group for all CBTE students on each of the ten attitude measures. Mean differences on one contrast were significant ($p. < .05$) and favored the CBTE students who participated in no concurrent field experiences. Although differences were negligible on the other nine contrasts, they favored the "materials only" group in each case.

The trend of the data suggests that CBTE students who have concurrent field experiences are less positive in their attitudes toward teaching specified science objectives than CBTE students who work only with CBTE materials.

Performance Ratings

Although sample sizes were small and suspect because of the rates of return, it was possible to compare the Field Experience II performance ratings in lesson planning, lesson teaching and total performance for 15 CBTE students who had a prior, concurrent field experience and 16 who used only the CBTE materials.

Table 16 shows means, variance estimates due to groups and sampling, and F-values for contrasts on each performance variable and the total performance score. Although the mean difference favors the group of students who had prior field experience which was concurrent with the science methods course, none of the differences is statistically significant. The data of this table shows that the directed teaching performance of CBTE students who had a concurrent field experience is no different than the directed teaching performance of CBTE students with no concurrent field experience.

TABLE 15: MEANS, STANDARD DEVIATIONS AND F-VALUES FOR COMPARISONS AMONG CBTE STUDENTS WITH AND WITHOUT CONCURRENT FIELD EXPERIENCE ON TEN MEASURES OF ATTITUDES TOWARD TEACHING SCIENCE OBJECTIVES.

Concepts	Groups		F-Values
	Materials (N-30)	Field Experience (N-60)	
Teaching students to:			
1. Believe in science as a means of dealing with real problems	32.40 (2.62)	30.75 (4.01)	4.180*
2. Interpret a table of data	30.97 (5.03)	30.30 (4.16)	0.451
3. Be willing to subject data and opinions to criticism	32.47 (2,96)	31.27 (3.89)	2.210
4. Collect data using five senses	33.83 (2.35)	33.47 (2.25)	0.496
5. Seek clarification of another's point of view	31.83 (3.72)	31.24 (3.83)	0.484
Teaching students about:			
6. Molecules and heat energy	29.00 (4.91)	28.97 (3.71)	0.002
7, Space	30.93 (3.76)	30.19 (3.96)	0.722
8. The Earth's changing surface	30.63 (3.47)	30.57 (4.17)	0.005
9. Light energy	29.47 (4.92)	28.88 (4.16)	0.356
10. Seeds and plants	31.87 (3.20)	31.44 (3.91)	0.272

*Significant at $p < .05$.

TABLE 16: MEANS, VARIANCE ESTIMATES, AND F-VALUE FOR COMPARISONS BETWEEN CBTE STUDENTS WITH AND WITHOUT CONCURRENT FIELD EXPERIENCES ON THREE FIELD EXPERIENCE II PERFORMANCE MEASURES

Variable	Group	N	Mean	Source	d.F.	Variance	F
Lesson Planning	MAT	16	11.25	Groups	1	15.138	0.868
	FIELD	15	12.67	Error	29	17.439	
Lesson Teaching	MAT	15	15.53	Groups	1	4.034	0.348
	FIELD	15	16.27	Error	28	11.595	
Total	MAT	15	27.60	Groups	1	13.334	0.468
	FIELD	15	28.93	Error	28	28.519	

Summary of Effects of Concurrent Field Experience

Comparisons of students who participated in observing and mini-teaching concurrent with their modularized CBTE experience in science methods to students who only use the CBTE materials failed to reveal differences in achievement, perceptions of various sources of instructional support, nine of ten attitudes toward teaching measures, and three measures of performance during a second field experience.

The groups differed significantly with respect to their attitudes toward teaching students to "believe in science as means of dealing with real life problems." This difference favored the group with no concurrent field experience. In addition, although mean differences were small for the nine other attitude measures they consistently favored the "materials only" group of CBTE students. The trend was suggestive of possible attitude differences, with students engaged in concurrent field experiences taking a less positive view of teaching science than students who do not have such experiences. A possible interpretation of this data is suggested by the hypothesis that concurrent field experiences introduce an element of reality about the complexity of teaching science which has a measurable negative effect on attitudes toward teaching science. This effect appears to be inconsequential, however, in relation to the achievement of students in the science methods course, their perceptions of the instructional environment, and their subsequent performance in directed teaching.

VALIDITY OF SELF-RATED ACHIEVEMENT

A study of the validity of self-rated achievement was conducted with 79 students who participated in the Revision Tryout of CBTE materials during the Fall of 1974. Measures of self-rated achievement on 25 course related goals, course achievement scores, total university grade point average, number of semester hours in science courses, and attitudes toward MYSELF-AS-A-TEACHER and MYSELF-AS-A-SCIENCE-TEACHER were factor analyzed to determine the components of self-rated achievement and the relationship of these components to prior achievement, prior experience in science, and self-rated attitudes.

Table 17 presents the means and standard deviations of each variable in the analysis.

TABLE 17: MEANS AND STANDARD DEVIATIONS OF 25 SELF-RATED ACHIEVEMENT SCORES, G.P.A., SEMESTER HOURS OF SCIENCE, AND TWO SELF CONCEPT MEASURES

Variable	Mean	Std. Dev.
Self-Rated Achievement[a]		
1	4.01	.650
2	4,24	.582
3	3.92	.730
4	3.70	.705
5	3.77	.733

TABLE 17: (Cont'd.)

Variable	Mean	Std. Dev.
Self-Rated Achievement[a]		
6	3.52	.617
7	3.80	.687
8	4.27	.655
9	3.42	.826
10	3.37	.754
11	3.84	.854
12	3.86	.780
13	3.82	.859
14	3.71	.879
15	3.81	.752
16	3.48	.959
17	2.19	1.122
18	2.30	1.213
19	4.08	.859
20	3.70	.979
21	3.76	.738
22	3.67	.858
23	3.56	1.035
24	3.89	.862
25	3.91	1.052
Course Achievement	44.89	2.380
G.P.A.	2.99	.563
Science Hours	21.41	14.663
MYSELF-AS-A-		
TEACHER	29.95	3.980
SCIENCE TEACHER	27.72	4.249

[a]Self-rated achievement on each of 25 course goals. Course goals used in ratings are identified in Appendix B.

The principle-factor solution rotated to the normal varimax criterion yielded nine factors. Six of these factors, the first five extracted and the last extracted accounted for 83.9 percent of the variance and were essentially independent self-rated factors. These factors and the variables which loaded greater than .40 on them are listed in Table 18.

These factors appear to be ammenable to interpretation as competence areas in science instruction. They are roughly comparable to but not identical with the competence areas generated by the Project Planning Team.

Factor 1 is made of items relating to the evaluation and use of existing curriculum materials and the ability to create new materials and teaching aides. This factor which accounted for approximately 43 percent of the total variation may be called "Curriculum Competence."

Factor 2 is composed of items which include the ability to recognize behaviors which are indicators of achievement to generate behavioral objectives. To some extent this factor, which accounted for approximately 13 percent of the total variation, may be interpreted as competence in a "behavioral orientation."

Factor 3, which accounted for about 10 percent of the total variation, includes just two variables which may be labeled "competence with State Minimal performance objectives."

Factor 4, accounting for 8 percent of the total variance, appears to be mainly a competence in "questioning strategies."

Factor 5 includes five variables relating to science-as-a-process, developing inquiring skills, and knowing how to use initiating and focusing teaching tactics. It may be labeled "inquiry-oriented teaching" competence and accounts for 7 percent of total variation.

TABLE 18: SIX COMPONENTS OF SELF-RATED ACHIEVEMENT IDENTIFIED IN THE FACTOR ANALYSIS

Factor	Loading	No.	Variable Description
1	.78	12	Ability to analyze and evaluate curriculum materials in science
	.70	11	Knowing scope and sequence of curriculum materials in science
	.64	19	Knowing how to review and evaluate textbook series in science
	.47	24	Able to construct teaching aides for science
2	.81	22	Ability to recognize behavioral indicators of achievement
	.73	20	Ability to generate objectives
	.58	23	Able to identify environmental awareness activities
	.52	21	Able to generate short term teaching strategies
3	.98	18	Ability to use State minimal performance objectives in science
	.80	17	Knowing State minimal performance objectives in science
4	.84	09	Ability to distinguish different kinds of questions
	.69	10	Ability to ask questions which encourage pupil use of intellectual skills
	.50	14	Ability to write instructional objectives for science unit
5	.63	1	Understanding science-as-process vs. science-as-knowledge
	.59	5	Knowing how to use focusing tactics in short-term teaching strategies
	.53	2	Knowing how to use inquiry skills
	.51	4	Knowing how to use attention-getting initiating tactics
	.50	3	Ability to plan activities which emphasize inquiry skill development
9	.63	6	Knowing how to encourage application of concepts, principles and skills through use of extending tactics

TABLE 19: THREE ADDITIONAL FACTORS IDENTIFIED IN FACTOR ANALYSIS

Factor	Loading	No.	Variable Description
6	.79	27	Grade point average for all courses
	.49	15	Able to identify useful and needed resources to teach science unit.
7	.70	29	Attitude Toward MYSELF-AS-A-TEACHER
	.56	30	Attitude Toward MYSELF-AS-A-SCIENCE-TEACHER
	.49	07	Knowing how to use terminating tactics in teaching
8	.70	08	Understanding the role of teacher questions in guiding learning
	-.50	28	Semester hours in science

Factor 9, which accounts for about 4 percent of the total variation, is a competence in using "extending tactics" in teaching science.

Three additional factors identified in the analysis load primarily on achievement, self-concept, and prior science experience respectively. One self-rated achievement variable is loaded on each of these variables. In two cases the relationship of self-rated achievement to the factor is negative. Table 19 describes these factors and the variables which have headings of .40 or more on each factor.

Course achievement measured by the points students achieved on modules did not contribute significantly (i.e. have loading greater than .40) to any factor. This variable, as might be hypothesized for any score which summarizes student achievement in a competency-based course, exhibited little variability. It correlated highest, .33, with Factor 6, which also included grade point average.

Summary

Self-rated achievement scores cluster in interpretable factors. These appear to be independent of prior achievement as represented by grade point average for all courses and two dimensions of self-concept assessed in the study. Whether or not the self-ratings have validity as measures of course achievement is a question which is not sufficiently resolved in the current study. A measure of course achievement based on points accumulated in the course did not correlate significantly with any identified factor. This was considered to be a function of the restricted range of these scores.

V
CONCLUSIONS

In this study an attempt was made to develop, evaluate, and revise competency-based materials in science methods education. The development phase was successful in identifying competencies and generating four modules which were assessed in Initial and Revision Tryouts with two waves of students. Data was collected and analyzed with respect to four major questions: What are the outcomes of competency-based instruction in science at CMU? Do CBTE science students differ from non-CBTE students in achievement, perceptions of achievement support, attitudes and directed teaching performance. Do CBTE students who have concurrent field experiences differ from those who do not in achievement, perceptions of achievement support, attitudes toward teaching science, and performance in directed teaching? What do self-ratings of achievement measure?

Conclusions and recommendations relating to each of these questions are discussed below.

Outcomes of CBTE Instruction and Comparative Evaluation

Students in CBTE sections of the science methods course achieve 75 percent of the course related objectives at better than a satisfactory level. Comparison scores on self-rated achievement for CBTE and non-CBTE students showed significant differences favoring the CBTE group.

However, achievement of objectives relating to State minimal performance objectives were unsatisfactorily accomplished by students in both the Initial and Revision Tryout of CBTE materials. While the State minimal performance objectives were used as the bases for the process module (observing, classifying, measuring, etc.), it appears that students had difficulty in translating this information back to the original source. They did well on the "process" items on Table 4, page 41, but seemed to view questions about State minimal performance objectives in isolation or separate from the skill areas in which they worked. In the continuing development of the CBTE effort in science, more attention should be given to the application of the State minimal performance objectives in a variety of situations.

Students in CBTE methods view independent, activity-oriented assignments as more significant in contributing to their achievement than instructor interactions or printed materials. In addition, CBTE students attribute their achievement in the course to independent activities and personal effort to a significantly greater degree than non-CBTE students. The data relating to student perceptions of learning activities and instructional support are entirely consistent with the expectations generated by the general philosophical framework of a competency-based approach. These data provide a basis for concluding that the student experience in CBTE sections is different than it is in non-CBTE sections and that it tends toward individualization, independence, and an activity-orientation.

In general, student attitudes toward teaching science are not greatly different at the conclusion of the science methods course than they were at the beginning. Comparisons between CBTE and non-CBTE students on measures of attitudes toward teaching 10 specific science objectives resulted in no significant differences. If student attitudes toward teaching science and other affective objectives are considered important in the context of this course, then more direct efforts should be taken to accomplish these objectives. It is possible, however, that students have more positive attitudes toward teaching science than is generally believed. Scores on the attitude measures used in the current study clustered toward the upper end of the scale.

Outcomes of CBTE Instruction and Comparative Evaluation (Cont'd.)

Comparing measures of attitudes toward MYSELF-AS-A-TEACHER and MYSELF-AS-A-SCIENCE-TEACHER, CBTE students showed significantly less positive attitudes toward MYSELF-AS-A-SCIENCE-TEACHER. A CBTE science methods course does not appear to develop self-concepts which are congruent with respect to these two dimensions.

Performance ratings of CBTE students during a directed teaching experience were generally positive. Areas of weakness included planning for the evaluation of a lesson and identifying achievement indicators. These weaknesses were also identified in self-rated achievement measures given at the end of the Initial Tryout period. Data collected at the end of the Revision Tryout suggest that such skills are better developed in the revised materials. Comparisons among CBTE and non-CBTE students on performance in lesson planning, lesson teaching, and combined performance score failed to result in significant differences.

Value of Concurrent Field Experience

Comparisons among CBTE students who participated in a concurrent field experience and those who did not on measures of achievement, perceptions of achievement support, and performance in lesson planning and lesson teaching yielded generally null results.

For one measure of attitudes toward teaching science students who participated in concurrent field experiences were significantly less positive than those who did not. In addition, the direction of non-significant differences on all nine other measures established a trend favoring the students who worked with CBTE materials only and did not participate in concurrent field experiences.

Value of Concurrent Field Experience (Cont'd.)

Apparently, if a concurrent field experience has any effect at all, it is to introduce the complexity of teaching science in a way that tends to overwhelm the student and lower attitudes toward teaching science. This effect seems not to have any consequences, however, for the achievement or achievement related perceptions of the student during the course, nor for his performance in subsequent directed teaching experience.

Validity of Self-Rated Achievement

Self-ratings of achievement appear to have validity as measures of student accomplishment of specific course goals. They are useful in distinguishing between CBTE and non-CBTE students, i.e., they show a significant mean difference for these two groups. In addition, aspects of achievement which were rated low by students own self-ratings were supported by subsequent ratings of supervising teachers during directed teaching, i.e., the difficulty in planning evaluation of lessons and in recognizing achievement indicators in the behavior of children.

A factor analysis of 25 self-ratings and five other variables (course achievement, G.P.A., semester hours in science, attitudes toward MYSELF-AS-A-TEACHER and MYSELF-AS-A-SCIENCE-TEACHER) resulted in the identification of 6 components to the self-ratings. These six components were independent of all other measures. However, the question of the validity of self-rated achievement as a criterion in the CBTE science methods course was not adequately resolved by the factor analysis study. The variable "course achievement" did not load significantly on any factor.

Summary

In summary, the CBTE effort in science methods has been responsible for generating a different approach to University level instruction. Student achievement of specified goals is greater than in the traditional program and study perceptions of the instructional experience suggest that competency-based instruction emphasizes, more than the traditional approach, such things as independent, activity-oriented, assignments and that such assignments contribute more to success in the course than instructor interactions or assigned readings from text.

However, the successes of the CBTE science methods course do not appear to be translated into differences in behavior during a later directed teaching experience. Overall CMU students are viewed as successful in lesson planning and lesson teaching in the directed teaching experience whether they participate in CBTE or non-CBTE sections of the science methods course.

The data of the current project suggests that CBTE has effects at the level of the University classroom, but that these effects are not translated into behavioral differences in the classroom. The presence or absence of field experiences concurrent with the CBTE modules does not seem to moderate these results.

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