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ABSTRACT

This monograph outlines the impact of competency-based teacher education (CBTE) on the science program for prospective elementary teachers at the University of Georgia and the conversion to a model which reflects CBTE philosophy. The introduction describes the general trend in science courses toward CBTE, starting with the establishment of a Regents Core Curriculum in 1967. There follow essays by professors in the science department that outline the development of a CBTE approach in courses for the following areas: chemistry, biology, geology, and physics. (JA)

A MODEL FOR THE ACADEMIC SUPPORT OF C.B.T.E.:

COMPETENCY-BASED SCIENCE FOR ELEMENTARY TEACHERS

edited by
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INTRODUCTION

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Competency-based teacher education (CBTE) is perhaps the most significant movement in teacher education in years. Viewed by some as a fad which will quickly pass, it may be a mechanism for effecting improvements in teacher training programs. Undoubtedly the move to restructure teacher education reflects a degree of dissatisfaction with public education and teacher quality. However, the earliest forces energizing the CBTE movement are obscure in educational history. Certainly a significant landmark is the development of Elementary Teacher Education Models sponsored by the Bureau of Research, U.S. Office of Education. Eighty design proposals resulted in funding for the development of nine models. U.S.O.E. outlined the problem as follows:

> Because of the key role that the teacher plays in facilitating learning, particularly with young children, he/she must have the most up-to-date *theoretical and substantive knowledge and professional skills to perform successfully* (italics mine). To date, research and development activities have generated new knowledge, materials, and methodologies with great potential for improving the effectiveness and efficiency of the teaching-learning process. If funds are made available, institutions should be able at this time to completely restructure their teacher education programs to include the best of what is now known and available. (October 16, 1967)

Thus, in 1967 U.S.O.E. had prescribed the essential attributes of CBTE--specification of knowledge and skills necessary for successful performance in the classroom. The challenge to teacher training

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*Dr. Capie is an elementary specialist who has co-ordinated a C.B.T.E. Program. He and other elementary science personnel at the University of Georgia have helped provide direction for the planning of the science preparation of elementary teachers. He was asked to summarize the C.B.T.E. movement, the factors which led to its emergence in the science areas at Georgia, and to summarize the significance of the curricular changes.

institutions was then, and still is, to specify in considerable detail the performances necessary to effective teaching; the knowledge-base prerequisite to competent performance; the means necessary to develop the competencies; and the assessment procedures required to evaluate competence. The model programs described professional competence more explicitly than subject area competence. The various aspects of teacher performance were delineated in some detail, but subject area knowledge and skills such as science were treated globally in the model programs.

Subsequent implementation has been effected without the massive funding implied in the original call for proposals. Consequently, development has been somewhat piecemeal and largely restricted to the education components of preservice programs. Altering the professional sequence may not be sufficient in order to fully implement the CBTE concept. Significant changes in the entire program of studies may be necessary.

This bulletin outlines the impact of CBTE on the science program for prospective elementary teachers at the University of Georgia and the conversion to a model which reflects CBTE philosophy. Sufficient progress has been made so that effective developmental, instructional and assessment strategies can be identified. The remainder of the Introduction outlines the program as it was in the late sixties and describes the forces influencing program evolution. Subsequent sections of the monograph include descriptions of the various components of the science program along with a description of essential aspects of development. The conclusion describes the impact of the special support courses on science methods and CBTE.

The Starting Point in Science

The University of Georgia produces a large number of elementary teachers each year (in excess of 350). Approximately 60 per cent of the university's graduates transfer from junior colleges at the beginning of their junior year. In response to a student demand for mobility or flexibility, the Regents in 1967 established a Regents Core Curriculum. It allowed students to complete the first 90 quarter hours of any program at any state institution. The Regents Core Curriculum also specified a minimum credit requirement in the humanities and natural sciences. Individual schools and colleges are free to present particular courses and to go beyond the minimum number of credits.

The science course combination for elementary majors which existed in 1967 consisted of 20 quarter hours of science--10 in biological science and 10 in physical science, 10 of which had to be a lab sequence. A three quarter hour methods course was included in the professional sequence of the College of Education. The courses selected from the regular Arts and Science offerings included

BIOLOGY 101 Four lectures and one 3-hour laboratory. Biological structure; the evolution, reproduction and development of organisms: the physical and chemical organization of protoplasm and cells.

BIOLOGY 102 Four lectures and one 3-hour laboratory. Biological function; bioenergetics of cells, cellular and organismal physiology, genetics, differentiation, behavior, ecology and evolution.

BOTANY 121 Four 1-hour lecture periods and one 3-hour laboratory period. A study of the biology of plants including cell structure and function, plant structure, growth and function and basic ecology.

BOTANY 122 Four 1-hour lecture periods and one 3-hour laboratory period. A study of (a) heredity, variation, and evolution of seed plants; (b) representative members of each of the major plant groups; and (c) the relations of plants to their environment.

GEOGRAPHY 104 An introduction to physical geography, surveying climate, vegetation, soils, landforms, and water resources in their areal interrelations and distributions.

GEOLOGY 125 Three lectures and two laboratory periods. Fundamentals of physical geology. Nature and origin of minerals and rocks. Agents of erosion, development of land forms, sedimentation, vulcanism, metamorphism, origin of mountains.

GEOLOGY 126 Three lectures and two laboratory periods. A continuation of Geology 125. Methods by which earth history is interpreted. Geologic history of North America by areas. Time scale. Evolution of plant and animal kingdoms.

ASTRONOMY 291 Five lectures per week. A survey of the planetary system followed by a more extensive discussion of stars, nebula, galactic and stellar structure and evolution, exterior galaxies and cosmology based on modern astrophysical theories and techniques.

PHYSICS 101 Five lectures per week. A survey to give an elementary knowledge of fundamental laws and concepts in physics and astronomy and to give an understanding of how the scientific method as exemplified by physical science has contributed to man's thinking.

Students met for three hours weekly in the methods course devoted to developing skills using science materials and processes and learning about science programs and resources. Six years later the required course credits remain unchanged--20 credits in science and three credits in methods. However the content of the courses and the approach has changed immensely, largely in concert with developments in CBTE. At Georgia, three factors were primarily responsible for the development of a new science program for elementary teachers--the development of the Georgia Educational Model, the influence of the Georgia Science Teacher Project, and the emergence of key people in the College of Education cooperating with various departments in the College of Arts and Sciences.

Although the U.S.O.E. funded model programs have had great impact at many institutions, the effect has been particularly apparent at the University of Georgia. Movement toward CBTE within the College of Education has been continuous although the pace has varied. Some departments have made a great deal of progress by successfully encouraging departments in Arts and Sciences to offer special courses within a CBTE framework. The Department of Science Education has been particularly effective in cooperating with Arts and Sciences. This success is largely attributable to conjoinment with academic departments first initiated under the umbrella of the Georgia Science Teacher Project (G.S.T.P.) The G.S.T.P. was an N.S.F. sponsored effort involving six institutions in the University System. Early G.S.T.P. efforts involved only secondary programs, but provided lines for interdepartmental communication. Thus, when the C.B.T.E. movement grew at Georgia, the groundwork for progress in elementary science had been established through the G.S.T.P.

The writers of other sections of this monograph have been instrumental in continuing interdepartmental goodwill and translating ideas into action.

CHEMISTRY FOR PROSPECTIVE ELEMENTARY TEACHERS

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Historically, chemistry courses offered to elementary education majors have been of the survey or nonscience-major type. In many instances, these courses have not been appropriate for preservice teachers. This paper traces the development of a chemistry course at the University of Georgia that has been designed especially for elementary education majors. Among the points to be included are a rationale for the course and a brief description of how the course was developed and evaluated.

Rationale

In what ways have the traditional chemistry courses taken by elementary educational majors been inadequate? Is there really a need for a special course for these students? Basically, traditional chemistry courses taken by prospective elementary school teachers have been inadequate because they lacked relevance for the students. These courses often have been highly theoretical or mathematical. Chemistry courses for prospective elementary teachers often included little or no laboratory work--a marked contrast to the highly activity-oriented modern elementary science programs.

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*Dr. Phillips is a graduate of the University of Georgia where he was involved in developing Chemistry 105. He was asked to describe the approach used in developing and implementing the first of the series of science courses for elementary teachers.

Two questions may help point out that the needs of elementary science teachers are different from those of the typical student enrolled in a nonscience-majors chemistry course. Put yourself in the shoes of a chemistry teacher and ask yourself the following questions: What competencies related to chemistry would a nonscience major utilize four years after he took my course? What competencies would an elementary teacher utilize four years later? The answers to these questions are different. The elementary teacher routinely teaches several hours of science each week, a portion of which is chemistry-related. Preparation may include mixing and dispensing solutions and assembling various apparatus. Science Instruction in the elementary school requires knowledge and utilization of many chemistry principles, not just "scientific literacy" or "an appreciation of the role of chemistry in our lives", the avowed purpose of some introductory chemistry courses.

A second reason for offering a special chemistry course for elementary education majors is numbers. Many schools graduate more students with degrees in elementary education than any other major. The number of prospective students for this specialized chemistry course is sufficient in most institutions to make offering such a course feasible.

Procedures

Development of Chemistry 105 began in 1970. The goal was to produce a course that could meet the needs of elementary education majors better than existing chemistry courses at the University. Some important characteristics which were incorporated into Chemistry 105 are:

1. Stressing the chemistry content most useful in the elementary classroom.
2. Developing the competencies in chemistry expected of elementary teachers.

3. Using a laboratory-centered format with integrated laboratory and discussion which reflects the nature of modern elementary science.

4. Evaluating laboratory performance by means other than traditional laboratory reports.

5. Utilizing simple and inexpensive materials and equipment that are readily available.

6. Keeping chemistry quantitative, yet, requiring no mathematics beyond simple algebra.

7. Making the laboratory work instructive and enjoyable.

Development of the course began with a page-by-page analysis of six popular elementary science programs. Three were textbook series; the remainder were: Science--A Process Approach, Elementary Science Study, and Science Curriculum Improvement Study. A tabulation was made of the chemistry-related activities in the six programs. The second step was to identify the competencies in chemistry expected of elementary education majors at the completion of their undergraduate preparation. The recommendations of the 1970 AAAS report entitled, "Preservice Science Education of Elementary School Teachers" were followed because they were judged to be most appropriate for our goals, the most complete, and most easily translated into practice. Experiments were written to develop many of the AAAS competencies. Competencies not appropriate for development in a laboratory setting were included in the discussion portion of the course.

A class of 35 students initially evaluated the experiments according to two criteria: clarity of learning objectives and clarity of directions. In addition, experiments were submitted to a jury of experts in chemistry and chemistry education for evaluation according to four criteria: relevance to chemistry (instead of science in general), accuracy of scientific content, adequacy of safety precautions and warnings, and ability to develop certain competencies specified in the AAAS Guidelines.

In several instances, laboratory work preceded discussion of the same topics. Discussions frequently were used to help students derive laws or generalizations from the data and observations previously gathered in the laboratory. By preceding the discussion with laboratory work, students with weak science backgrounds were given concrete experiences to which they may have related and built upon as material was discussed in lecture.

An effort was made to have the laboratory work be instructive and enjoyable. The simplification of laboratory equipment and procedures minimized the confusion and frustration that so often occurs when laboratory work is complex. Scientific concepts were not hidden behind the means employed to discover them. Much of the tedium of laboratory work was eliminated by appropriate selection of experiments and willingness to accept relatively crude measurements done only once instead of requiring precise measurements done in triplicate.

Student laboratory work was evaluated by means other than paper-and-pencil tasks whenever practical. In many instances students were required to demonstrate certain competencies to the laboratory instructor as is done in Science--A Process Approach.

Current Status and Summary

Chemistry 105 has been offered every quarter since its inception. A graduate version of the course has been made available during the summer session. Presently, the course is five quarter hours--three credits for discussion and two credits for laboratory. Discussion sessions meet for three 50-minute perods each week. Laboratory consists of two 2-hour sessions each week. The course is an elective with no prerequisites.

No commercially available textbooks were considered satisfactory for the course. Consequently, a manuscript which incorporated revised and new experiments with textual material in an integrated format was prepared for student use. In each chapter the experiments are placed where they are judged to be most appropriate. At times experiments are used to introduce concepts discussed later in the textual portion of the book. At other times experiments are placed following the textual material so as to supplement and reinforce an idea.

The success of the course is gratifying. More elementary education majors are electing chemistry as a physical science elective. A large percentage of the Chemistry 105 students have expressed opinions that what they have learned would be useful in their teaching. Finally, the success of the "pilot" program in chemistry paved the way for similar courses in geology, physics, and biology at the University.

PLANNING COMPETENCY BASED BIOLOGY FOR ELEMENTARY EDUCATION MAJORS

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It is the purpose of this section to outline the planning sequence that led to the development of Biology for Elementary Teachers - An Ecological Approach (BIO 105). This section will emphasize the development of this course in the context and spirit of competency based education.

Needs Assessment

By the end of 1972-73 academic year special courses for elementary education students had been developed in chemistry, physics and geology. During that year a survey of 100 students majoring in elementary education revealed the following:

1. Over sixty percent of this student population had not taken BIO 101 and BIO 102, the introductory biology courses taught within the Division of Biological Science.
2. Most students, rather, seemed to be satisfying their biological science requirement by taking biology at other schools in the summer or enrolling in botany, horticulture, or other specialized or applied courses.
3. All 100 students indicated that if a special biology course for elementary education students were offered, they would register for it instead of BIO 101 and BIO 102.

Members of the Department of Science Education had noted for some time that many elementary teachers were reluctant to teach science. One reason for this has been (according to the teachers) that their under-

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*Dr. Simpson has taught elementary science as well as graduate biology. He has cooperated in the planning and implementation of BIO 105. He was asked to detail the planning approach used in BIO 105 which is representative of planning of all courses which followed chemistry.

graduate college science experience left them with negative attitudes toward science and feelings that they did not know enough about science to teach it. More specifically, many elementary teachers have stated that their introductory biology course did not include ideas that they could use in their teaching.

As a result of the aforementioned needs a committee was established by the chairman of the Division of Biological Sciences to prepare a course suitable for prospective elementary teachers. The committee was comprised of two faculty members from the College of Arts and Sciences (one from Entomology and one from the Botany Department) and a faculty member from the Department of Science Education.

The three-member committee met and established parameters, guidelines, and general objectives for the proposed course: Biology for Elementary Teachers - An Ecological Approach (BIO 105). A later, nonsequential course to be called Biology for Elementary Teachers - A Cultural Approach (BIO 106) was also proposed.

Major Objectives of Biology 105

It was the unanimous judgement of the committee that BIO 105 should attempt to stimulate and develop the following three areas:

1. Knowledge of major concepts in biology
2. Competence in Processes of scientific inquiry
3. Positive attitudes toward science

These broad objectives attempt to meet the needs of prospective elementary science teachers and are in harmony with the guidelines that appear in the American Association for the Advancement of Science's <u>Guidelines for Preservice Education of Elementary Teachers</u>. The following guidelines correspond to the objectives above:

1. The content of college science experiences for elementary teachers should be selected so that the topics studied by teachers provide,—as a minimum, an adequate background for the topics taught in elementary schools.

2. The science experiences for elementary teachers should develop competence in inquiry skills or processes of scientific inquiry.

3. Science experiences for elementary teachers should develop an appreciation for the historical, philosophical, and current significance of science to society, an increased interest in science-related activities, and positive attitudes about science which result in improved science teaching in their classrooms.

Criteria Used in Selecting Concepts in Biology

In an effort to specify the most important biological concepts relevant to the needs of elementary teachers the committee used several references. The major sources were:

1. National Science Teachers Association Conceptual Schemes

2. Wisconsin National Panel

3. Grobstein's Biological Concepts

4. Biologic Content of Elementary Science Study (ESS), Science--A Process Approach (S--APA), and Science Curriculum Improvement Study (SCIS)

5. CUEBS: Evaluation in the Biological Sciences

6. Major Principles from the Biological Science Curriculum Study

The two most helpful sources were the major concepts from the Wisconsin Panel and the actual Biological content found in the three major elementary science curriculum projects (ESS, S--APA and SCIS). The committee established concept priorities and classified concepts around major topical areas. It was strongly recommended that Biology 105 contain an ecological approach to the major topics incorporated into this course.

After classifying the major biological concepts the committee agreed upon the following areas to be included in Biology 105: The Nature of Science, The Hierarchy of Biological Organization, Classification and Diversity among Living Things, Bioenergetics, Homeostasis and Regulation, Interaction, Behavior, Reproduction and Development, Genetic Continuity, Evolution.

Selecting Major Processes in Science

In line with the second course objective the committee explored the major processes inherent to science needed by future elementary teachers to effectively introduce children to science in the spirit of the federally funded curricula. The following sources were used in helping implement this object:

1. S-APA Processes
2. NSTA Processes of Science
3. SCIS Processes
4. ESS Processes
5. Processes in SPI Instrument

The common processes found in the various curricula and deemed important by the committee include:

Observing	Controlling Variables
Using Space-Time Relationships	Interpreting Data
Using Numbers	Defining Operationally
Measuring	Formulating Hypotheses
Classifying	Experimenting
Communicating	Inventing
Predicting	Discovering
Inferring	Curiosity

Developing Positive Attitudes Toward Science

A paramount deficiency of traditional sciences courses for prospective elementary teachers is the failure to develop positive feelings toward science. Science courses designated for academic majors are often perceived as difficult and esoteric by nonmajors. Perhaps the most important objective of this course is to produce positive and significant achievement in the affective domain. The committee was particularly interested in developing instructional strategies and modes of assessment to meet this objective. Proposed course evaluations include measuring (1) student preference for biology (2) student attitudes toward science (3) student attitudes toward the course, and (4) student adherence to science-related cultural values.

Instructional Strategies

Since Biology 105 has not yet been offered, a detailed description of the major instructional methods is unavailable. Instruction will be designed, however, to help students discover the major concepts of biology, develop competencies related to scientific processes, and encourage positive attitudes toward the scientific enterprise. Behavioral objectives have been written for each of the ten broad topical areas of the course. The objectives will be used to communicate to the student the behaviors, skills, and competencies expected of them. Instruction will provide for:

1. Student-centered activities.
2. Learning by inquiry and discovery.
3. Some self-paced, individualized instruction with optional learning pathways.
4. Emphasis on mastery as opposed to a set time spent on each topic.

The committee was unanimous in the belief that instruction in Biology 105 should reflect the spirit of the major elementary science curricula and demonstrate strategies for presenting science to elementary students.

Evaluation

Pre- and post testing assessing the following areas will be implemented in this course:

1. Knowledge of major biological concepts.
2. Ability to perform basic scientific processes.
3. Attitudes toward biology and science
   a. subject preference scale.
   b. scientific attitude.
   c. cultural values.

Evaluation and assessment of student achievement will be based specifically on the behavioral objectives presented at the outset of each unit or module. Student grades will be criterion referenced as opposed to norm referenced. Emphasis will be placed on gains made from beginning to end of the course.

THE INSTRUCTIONAL COMPONENTS OF GEOLOGY 105,
COMPETENCY-BASED GEOLOGY FOR
ELEMENTARY TEACHERS

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Geology for Elementary Teachers was developed primarily to provide prospective elementary teachers with selected principles of science derived from geology as a body of knowledge and a scientific endeavor. The course was intended to provide experience with methods of learning geology and the geological information most likely to be needed by teachers in the elementary school. The students were told that experiences and content encountered in the course were carefully chosen with elementary teaching requirements in mind. They were also informed that the course does not represent a body of owledge that can be transmitted directly to elementary school students. The rationale was that in order to teach any subject with confidence a enthusiasm a teacher must know considerably more than the students are xpected to learn. The course did not attempt to anticipate the problems, questions and interests of future students or new developments in science. Instead, a reasonably broad background and a satisfying experience in learning geology were provided. The goal was to prepare a preservice elementary teacher to direct the learning of their students in the field of earth science

Instructional Components

Seven instructional elements were identified in the development and

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*Dr. Shrum has taught geology and Earth science from middle school through graduate level. He has helped plan and teach Geology 105 with geology faculty. He was asked to describe the content and instruction of GLY 105.

implementation of Geology 105. These course components were: (1) course mechanics, (2) topics included, (3) use of the laboratory, (4) use of modules, (5) self-pacing, (6) competency based, and (7) evaluation. The combination of these components and the manner in which they have been implemented are unique in the offerings of the Geology Department at the University of Georgia.

Mechanics of the Course

Geology 105 utilizes instructional modules which are completely self-contained and through which students proceed more or less at their own pace. No formal lectures or other meetings are held after the first class meeting when the course organization is explained. No textbook is required; an optional textbook is suggested and available in the bookstore.

The course has a regularly scheduled class hour for each section although the students are free to come to the classroom-laboratory anytime they choose between eight AM and five PM. The faculty member in charge of each section is available in the classroom during the designated course hours; a graduate student is on duty in the classroom at other hours during the day, five days per week. Help is thus available for anyone having questions or problems or who wants to challenge any of the ideas or information in the course.

Topics Included

Seven topics representing major concepts in geology were selected for the course. The criteria for selection were relevance to topics encountered in elementary school science and geologic concepts of value for general education purposes. The seven topics were: (1) The Earth as a Planet, (2) Earth Materials, (3) Earth Processes, (4) Earth Structure, (5) Earth's Surface, (6) Geologic Time, and (7) Earth History. Seven modules prepared on these topics were immediately revised into twelve modules to avoid excessive length. Experience with the twelve modules resulted in subdividing one additional module and adding a summary module which helps the student interrelate other modules in the context of understanding the geology of Georgia.

Geology 105 is now organized into fourteen modules having the titles listed below. The number in parentheses refers to one or more of the seven topics listed above from which the module was derived.

Module	Title	Topic Source
1	The Earth	(1)
2	Earth Materials, Part I: Minerals	(2)
3	Earth Materials, Part II: Rocks	(2)
4	Waters of the Land	(2)
5	The Land Wears Away	(3-5)
6	Mountains from the Sea	(3-5)
7	Rock Deformation	(3-4)
8	Interior of the Earth	(4)
9	Geologic Time	(6)
10	A Survey of Ancient Life, Part I	(7)
11	A Survey of Ancient Life, Part II	(7)
12	Preservation and Significance of Fossils	(7)
13	Fossils in Paleobiology and Geology	(7)
14	Geology of Georgia	(1 through 7)

Use of the Laboratory

All work in the course is done in a classroom-laboratory equipped with tables, sinks and audio-visual facilities. The results of outside observations are used in the laboratory. The emphasis on a laboratory setting is central to the philosophy of individualized study involving both discovery and activity as learning methods.

Use of Modules

Modules are the basic instructional unit in the course. They provide the entire course organization and content for the students. Modules instruct the students through narrative discussion and explanations, questions, activities, and the use of ancillary materials such as books, maps, rock, mineral and fossil specimens, color slides, and experimental apparatus. The students have access to all the needed materials right in the laboratory or in contiguous storage areas. Normally the students obtain the materials needed and return them to storage; the instructor or graduate student helps locate material if necessary.

Self-pacing

Self-pacing with flexible availability of instructional facilities is an important component of individualized instruction. Geology 105 used a modified form of self-pacing. Ideally a self-paced modular course would impose no examination schedule upon the student. The modification used in Geology 105 is that while the student may complete the modules at any pace, examinations can be taken only at specified time intervals. Five examinations are given according to the following schedule: the examination over Modules 1 to 3 is given during Week 4, Module 4 to 6 examination is administered during Week 6, Modules 7 to 9 during Week 8, Modules 10 to 11 during the scheduled time in Final Week. The modification of scheduling time intervals when the examinations can be taken provides a basic schedule which assures a reasonable rate of progress through the course.

Competency-based

Geology 105 is considered to be a modified form of competency-based instruction. In order to be completely competency-based, each module would have to have objectives specified in behavioral terms, provide both pre- and post-assessment and the information and activities for learning the module itself. Pre-assessment would enable a student to obtain credit for a module if the demonstrated proficiency indicated prior achievement of the desired objectives. In Geology 105, a minimum level of proficiency is expected on the five examinations over the modules. A capable student could do a minimum amount of work in the module itself and still attain a satisfactory score on the examination over the module.

Evaluation

Evaluation in Geology 105 is conducted for four purposes: to indicate level of competence, to provide data for determining course grades, to provide information on the effectiveness of instruction, and to provide information about the course itself. The evaluation model is similar to the plan in Physics for Elementary Teachers. Consequently discussion will be deferred to a subsequent portion of the monograph.

Course Acceptance

Geology 105 has been well received by students, geology faculty, and advisers in elementary education. Students have indicated through both informal verbal comments and responses to evaluation instruments that they consider the course to be valuable to them. Additional evidence is the increased enrollment each quarter the course has been offered. Two sections of twenty to twenty-four students are being offered each quarter. Preregistration requests indicate a third section could be offered at least two quarters during the academic year. Another indication that students value the course is the requests for copies of modules and other materials being used in the course. Students feel that personal possession of these materials will be helpful to them in their own teaching at a later date.

The enrollment growth in Geology 105 can be attributed to the value held for the course by the advisers in elementary education. Based on the experience of their advisees who have had the course, advisers are recommending that majors in elementary education enroll in Geology 105. Comments by these advisers attest to the relevancy and desirability of students having the experiences and geological background obtained in the course.

The acceptance of Geology 105 as a bona fide science course for preservice elementary teachers by the geology faculty is an important aspect of the course. The several instructors (four faculty members and two graduate students have been involved to date) have exhibited a great deal of enthusiasm for both geological content and methods of instruction used in the course. Each instructor has indicated that he either intends to or is already partially adopting the philosophy of modular and self-paced instruction in upper-division and graduate-level geology courses that he teaches. Several other geology faculty members admitted to skepticism of the approach being used in Geology 105 when they first learned about it. They have since been convinced through success of the course and enthusiasm of faculty dealing with it that Geology 105 is indeed a worthwhile offering of the Geology Department. As such, they have been willing to involve additional faculty and to assign graduate assistants to the course on a regular basis to accomodate growth and provide for future revision of the course.

ASSESSMENT OF A COMPETENCY-BASED SCIENCE PROGRAM: PHYSICS FOR ELEMENTARY TEACHERS

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Physics for Elementary Teachers was designed to develop concepts, skills, and attitudes prerequisite to successful elementary science teaching. The course differs from other available physics courses in three important aspects:

1. The content was selected according to the particular needs of elementary teachers.
2. A philosophy for teaching science was demonstrated by the instructional procedures selected for use in the course.
3. A self-paced, competency-based, modular format allowed for individual differences in achieving and demonstrating competence.

Many elementary science programs were examined before the course content was selected. Preference was given to significant topics possessing application value for teachers. The course content and topic sequence are shown in Figure 1. Each block represents an activity-centered, modular unit of study. In all activities students were made aware of the use of scientific processes such as observing, inferring, measuring, communicating, predicting, controlling variables, and formulating and testing hypotheses. Laboratory experiences were designed so that principles emerged from a study of concrete observations and first-hand interactions. Whenever possible, rules and principles were experimentally applied and tested in novel situations.

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*Mr. Markle is a teaching assistant who has taught high school physics and elementary science methods. He has been involved in the planning, implementation, and evaluation of Physics 105. He was asked to describe the evaluation of PCS 105 which has become a model for other 105 courses.

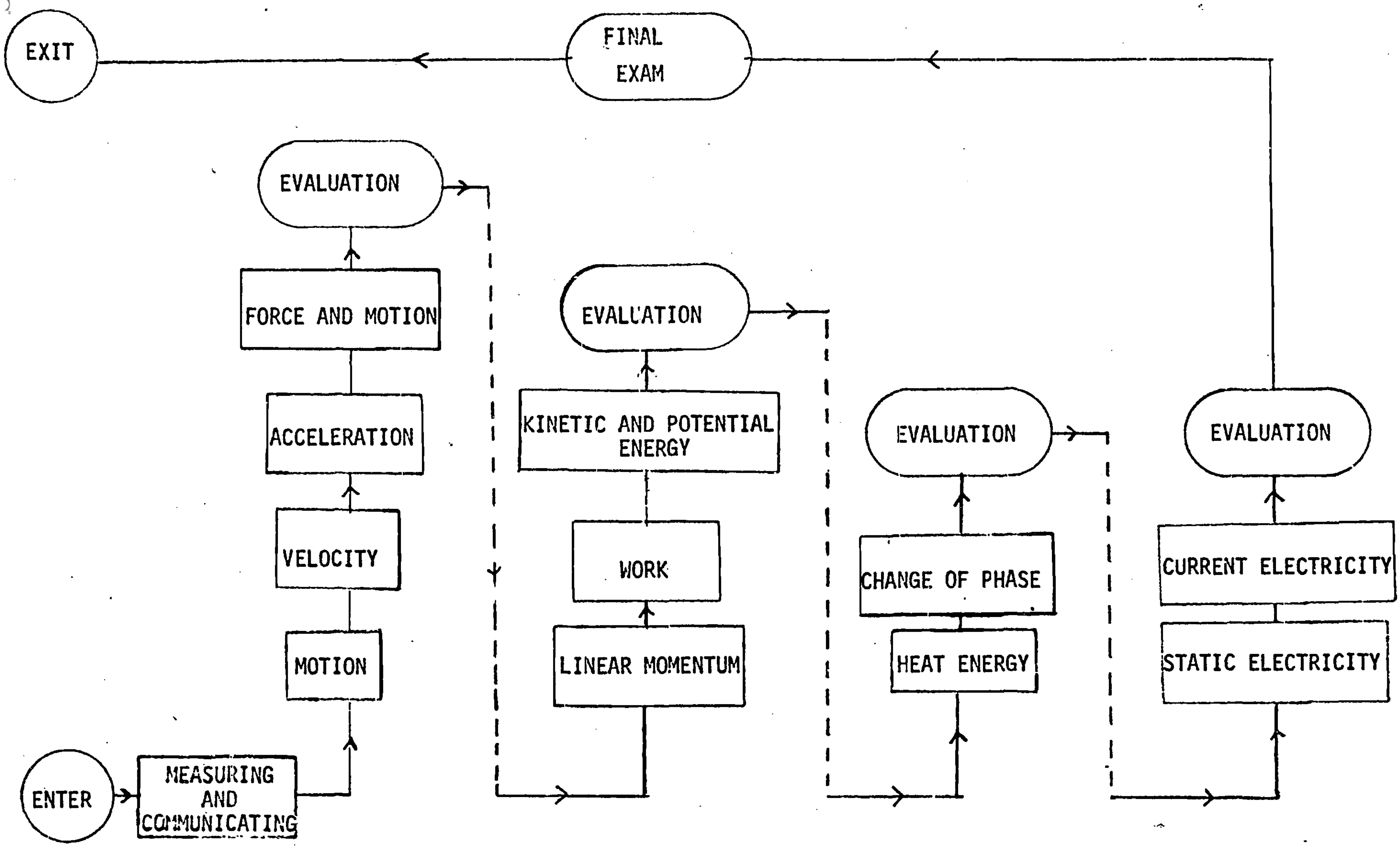

FIGURE 1. Course content and sequence for Physics 105, Physics For Elementary Teachers.

Individual student evaluation was based on achievement of the course objectives. The objectives for each module were stated at the outset. After completing the module, students were tested on the objectives. At the end of a cluster of several modules, students were given a one to two-hour examination on the objectives in that cluster. Cluster tests required activity-type responses, short answer responses, and problem solving. Success on these tests was defined as eighty percent correct. A student scoring below criterion had the option of retaking a similar test after extra instruction.

A midterm problem solving examination based on the information covered in the discussion sessions and a final examination covering all aspects of the course were also administered. The total evaluation of the student as announced at the beginning of the quarter, was determined as follows: successful completion of all modules and the corresponding module tests guaranteed a minimum grade of "C"; success on all cluster tests guaranteed a minimum grade of "B"; success on both of these plus a final examination grade of eighty-five percent or better resulted in a guaranteed "A."

Course Evaluation

Physics for Elementary Teachers was offered and evaluated during the spring and fall quarters, 1973. Three areas were assessed in evaluating the physics course: achievement of course objectives, knowledge of science processes, and attitudes toward science and the course.

Changes in Understanding of Relevant Concepts

A forty-four item multiple choice test emphasizing comprehension and application of course relevant concepts and science processes was constructed

Content validity was established through examination of the instrument and course objectives by two members of the Physics Department and one member of the Department of Science Education. The test was administered at the beginning and end of each quarter. The average gain was approximately eleven points each quarter. The t-value for differences in individual scores was significant beyong the 0.001 level.[1] The results are shown in Table 1.

TABLE 1

Scores on a forty-four item course relevant test.*

	SPRING		FALL		COMBINED	
	Pre	Post	Pre	Post	Pre	Post
N	9	9	12	12	21	21
$\overline{X}$	18.44	30.22	17.92	28.67	18.14	29.33
s	6.60	4.65	4.91	3.89	5.54	4.20
t**	4.83^{t}		6.07^{t}		7.88^{t}	

*The respective KR-20 test reliabilities were 0.80; 0.72; 0.69; and 0.71.

**All t-values were determined for correlated means. All values followed by a t are significant beyond the 0.05 level.

Changes in Understanding Science Processes

The Wisconsin Inventory of Science Processes (WISP) was administered at the beginning and end of the spring quarter. This instrument had been used in previous research with preservice elementary teachers at the University of Georgia.[2] The validation procedures used in developing the WISP instrument were described by Stauss and Carey.[3] Form D of Welch Science Process Inventory (SPI) was administered at the beginning and end of the fall quarter. The validation procedure used for the SPI was similar to that for WISP and has been described by Welch and Pella.[4]

A comparison of the WISP scores for the assessment group and previous students revealed no significant differences. The mean score on the WISP increased by six points and on the SPI by five points. The t-value for matched cases was significant both quarters indicating real differences between the pre- and post-test scores. The results of each use of the process inventory instruments are shown in Table 2.

TABLE 2

Scores on tests to determine understanding of science processes: spring, The Wisconsin Inventory of Science Processes; fall, the Welsh Science Process Inventory.*

	SPRING		FALL	
	Pre	Post	Pre	Post
N	9	9	11	11
$\bar{X}$	59.22	66.00	106.73	112.00
s	9.77	8.29	8.89	5.85
t**	2.71^t		3.01^t	

*The respective KR-20 reliabilities were 0.84; 0.81; 0.78; and 0.80.

**All t-values were determined for correlated means. All values followed by a t are significant beyond the 0.05 level.

Evaluating Attitude Changes

Attitudes toward science and physics were measured using a forced-choice subject preference survey. Ten electives available to undergraduates were paired in all possible combinations. Students were instructed to circle the elective in each pair they would prefer or would recommend to a friend. The number of times a subject was selected became its score.

The subject preference survey was administered at the beginning and end of the spring and fall quarters. Kendall's coefficient of consistance[5] was calculated for each student. Any student with a consistance coefficient less than 0.80 was excluded from analysis.

The physics preference score at the end of each quarter was compared with the physics preference score at the beginning of that quarter. In addition, the selection of science subjects over non-science subjects was compared. The increase in physics selections was significant during the fall quarter but not during the spring quarter. The increase in the selection of physics was greater than that for any other subject during both quarters. The selection changes for other courses was not significant during either quarter. The results for physics selections are shown in Table 3.

TABLE 3

Selection of physics over other subjects on the subject preference survey.*

	SPRING		FALL		COMBINED	
	Pre	Post	Pre	Post	Pre	Post
N	9	9	11	11	20	20
$\overline{X}$	3.56	5.67	2.91	5.01	3.10	5.25
s	3.00	3.64	2.63	2.95	2.79	3.27
t**	1.43		2.42^t		2.64^t	

*The respective Kendall coefficients of consistency were 0.90; 0.92; 0.92; 0.94; 0.91; and 0.93.

**All t-values were determined for correlated means. All values followed by a t are significant beyong the 0.05 level.

Significant increases in the selection of science courses over non-science courses occurred during both the spring and fall quarters. The results are shown in Table 4.

TABLE 4

Selection of science subjects over non-science subjects on the subject preference survey.*

	SPRING		FALL		COMBINED	
	Pre	Post	Pre	Post	Pre	Post
N	9	9	11	11	20	20
$\overline{X}$	4.89	7.33	3.36	6.18	4.05	6.70
s	4.48	5.10	2.66	5.32	3.58	5.07
t**	2.80^t		2.57^t		4.18^t	

*The respective Kendall coefficients of consistency were 0.90; 0.92; 0.92; 0.94; 0.91; and 0.93.

**All t-values were determined for correlated means. All values followed by a t are significant beyond the 0.05 level.

<u>Assessing General Attitudes Toward the Course</u>

At the end of each quarter that the course has been offered, students were asked to complete an adjective check list in order to obtain a structured description of the course. For each word in the list, the student could indicate that the word was an apt descriptor of experiences in the course, that it was not an apt descriptor, or leave the word unchecked. In general, responses at the end of both quarters indicated positive reactions to the course. A summary of student responses is shown in Appendix A, page 33.

Conclusions and Recommendations

The competency-based science courses at the University of Georgia were designed to develop science concepts through an activity-based approach incorporating the processes of science. It was assumed that such a strategy would enhance a future teacher's understanding of science concepts and processes in addition to developing more positive attitudes toward science. Total program evaluation must be delayed until all courses have been implemented and sufficient numbers of students have completed each course. However, based on the physics data several tentative claims about the physics course can be made:

1. Physics content may be effectively taught to preservice elementary teachers using a self-paced, activity-centered, modular approach.
2. Preservice elementary teachers can increase their understanding of the processes of science as measured by the WISP and SPI tests by using the processes during a physics course.
3. Future preference for science courses can be developed in preservice elementary teachers through an activity-centered course relevant to their needs.
4. Preservice elementary teachers have a positive reaction to a self-paced physics course designed to meet their particular needs.

Informal feedback and systematic analysis of student success on each objective are providing the basis for continuous program revision. At the present time plans are being formulated for additional modules. A desireable model seems to be having a core of common modules and a variety of content options for students. Of course, science teachers must have subject matter competence before teaching any science, but attitudes and skills must be considered as well. The emphasis on process and affective goals will be retained in the physics program and probably expanded in other science areas at the University of Georgia. It is almost impossible to create positive attitudes and skills among elementary teachers in a one quarter methods program if they have taken traditional introductory courses. Such learning must occur in the context of meaningful science investigations. It would be regretable, indeed, if students who had the benefit of special courses for teachers failed to improve their attitude toward science.

APPENDIX A

Summary of twenty-one student responses to the adjective checklist used to describe Physics for Elementary Teachers.*

The course	was	was not		was	was not	
	20	0	DISCOVERY ORIENTED	13	1	STRUCTURED
	20	0	INFORMATIVE	12	1	MATURE
	19	1	BENEFICIAL	12	0	TRUSTING
	19	0	RELEVANT	11	8	FRUSTRATING
	19	0	HELPFUL	10	3	GROUP ORIENTED
	19	0	PREPLANNED	9	8	HARD
	19	0	USEFUL	9	8	NERVE-WRACKING
	19	0	ORGANIZED	6	13	BORING
	18	0	INFORMAL	6	10	DIFFICULT
	18	1	FAIR	5	10	COMPETATIVE
	17	1	EFFECTIVE	4	14	DREADED
	17	0	UNDERSTANDABLE	4	13	REPETITIOUS
	17	0	INDIVIDUALIZED	3	12	OVERLOADED
	17	0	REASONABLE	2	14	DISAGREEABLE
	17	1	WORTHWHILE	2	17	DISORGANIZED
	17	0	PARTICIPATORY	2	14	HARSH
	16	0	TRANSFERABLE	2	14	IMPERSONAL
	16	1	INDEPENDENT	2	14	RIGID
	16	2	INTERESTING	1	6	INCONSISTENT
	15	0	COOPERATIVE	1	17	PURPOSELESS
	15	3	ENJOYABLE	1	16	THREATENING
	14	2	FUN	1	18	UNREASONABLE
	13	1	PERSONAL	0	10	IRRELEVANT
	13	4	STIMULATING	0	17	MEANINGLESS

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*The adjectives in the summary table are arranged according to decreasing frequency of agreement. On the evaluation instrument, they were ordered alphabetically.

REFERENCES

[1]All t-values reported in this paper are related to the significance of the difference between two means for correlated samples. The calculation is described by Georga Ferguson in _Statistical Analysis in Psychology and Education_, McGraw-Hill, 1966, p. 169.

[2]Russell L. Carey and Nyles G. Stauss, "An Analysis of the Relationship Between Prospective Science Teachers Understanding of the Nature of Science and Certain Academic Variables", the _Bulletin of the Georgia Academy of Science_, Volume 27, June, 1969, 148-158.

[3]Ibid. p. 149

[4]Wayne W. Welch and Milton O. Pella, "The Development of an Instrument for Inventorying Knowledge of the Processes of Science," _Journal for Research in Science Teaching_, Vo. 5, pp. 64-68.

[5]Ferguson, op. cit., p. 228.

SCIENCE FOR ELEMENTARY TEACHERS--
ASSESSING THE IMPACT

William Capie

The most desirable variable to study in assessing the impact of the science program for elementary teachers is the teaching effectiveness of recent graduates. Such a study is not appropriate while the program is in its formative stages. Consequently, less significant, indirect indicators of progress must be sought. One significant factor in all courses offered has been steadily increasing enrollments. The data generated in evaluating individual courses are also encouraging. While each of these developments is desireable, none represents a real difference in the science teaching competence of Georgia graduates.

Changes in Science Methods

Striking changes in methods instruction have been facilitated as more and more students have completed portions of the 105 sequence. Until recently, a great portion of each methods course was devoted to three goals: (1) cultivating science process skills; (2) providing experiences in conducting investigations; and (3) partially eradicating negative feelings about science and science teaching. These goals are becoming obsolescent as students gain more experience in 105 courses. Physics and Biology, in particular, place great emphasis on process skills and seek to develop them in the context of meaningful investigation.

Students in Science Methods are then able to learn techniques for teaching and using science processes with children. In addition to learning about techniques, students go on to use the techniques with children in teaching situations in local schools. Such a practice has become possible as the demands to use methods classtime for science activities have diminished. Students are able to demonstrate knowledge of a technique, use of the technique in simulation as well as "real-world" settings. The reinforcement of having children enjoy science activities further strengthens the development of positive attitudes toward teaching science.

The emergance of the 105 course sequence has enhanced the teaching of science methods by assuming former methods content best learned in a science course and by strengthening weak science backgrounds. The large gain in methods appears to be time--time to teach science in local schools. The real benefit may be substance, however, since methods courses are becoming more devoted to methods and less to science content.

Changes in Programs

A most startling and pleasant change resulting from the 105 courses has been the use of science as an elective. Many students are electing one or more of the 105 courses where they formerly chose courses such as Health and Safety or Crafts for Teachers. Another positive development is an increase in the number of elementary majors who take all of the available science courses plus a second course in science education.

Limitations

All elementary students will not take four 105 courses to fulfill science requirements. Many take science courses at a junior college before coming to the University. Once here, an elementary major often desires a course with boys in it! Unfortunately, the 105 courses, and elementary education have yet to satisfy that wish to any great degree. While the 105 courses are proving attractive to many, they are creating more heterogeneity among methods students. The diversity has created an even greater need to individualize methods instruction. Fortunately, the emergance of C.B.T.E. program organization provides for differences in students' background so that variation has not been a great problem. Rather it has helped to emphasize the value of what has been done so far.