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STEPS TOWARD SCIENTIFIC LITERACY, A REPORT OF COLLEGE-LEVEL CONFERENCES ON SCIENCE FOR NONSCIENCE MAJORS.

NATIONAL SCIENCE TEACHERS ASSN., WASHINGTON, D.C.

PUB DATE 68

EDRS PRICE MF-$0.25 HC-$1.12 26P.

DESCRIPTORS- *BIOLOGY, *BEHAVIORAL OBJECTIVES, *CONFERENCE REPORTS, *COLLEGE SCIENCE, *EDUCATIONAL PROGRAMS, *EDUCATIONAL OBJECTIVES, *GENERAL EDUCATION, *UNDERGRADUATE STUDY, COURSE DESCRIPTIONS, CHEMISTRY, ELEMENTARY SCHOOL SCIENCE, HIGHER EDUCATION, PHYSICAL SCIENCES, SCIENCE EDUCATION, TEACHER EDUCATION,

DURING THE 1967-68 ACADEMIC YEAR, THE NATIONAL SCIENCE TEACHERS ASSOCIATION SPONSORED FOUR WORKING CONFERENCES WITH COLLEGE SCIENCE TEACHERS WHO WERE CONCERNED WITH TEACHING SCIENCE FOR THE NONSCIENCE MAJOR. THE TWO ASPECTS EMPHASIZED AT THE MEETINGS WERE (1) THE MEANING OF THE TERM "SCIENTIFIC LITERACY," AND THE IMPORTANCE OF PRODUCING COLLEGE GRADUATES WHO ARE LITERATE IN SCIENCE, AND (2) THE MEANING OF THE TERM "BEHAVIORAL OBJECTIVES" AND THEIR IMPORTANCE IN DEVELOPING SCIENCE EDUCATION PROGRAMS. THIS REPORT IS A SUMMARY OF SOME OF THE CONCLUSIONS THAT HAVE BEEN DRAWN FROM THE DELIBERATIONS OF THE WORKING GROUPS. PART 1 EMPHASIZES (1) THE STATEMENT OF GOALS FOR GENERAL EDUCATION SCIENCE COURSES, AND (2) THE DEVELOPMENT OF THESE OBJECTIVES INTO BEHAVIORAL TERMS. PART 2 PRESENTS (1) A DIALOGUE BETWEEN CONFERENCE PARTICIPANTS ON THE OBJECTIVES OF UNDERGRADUATE GENERAL EDUCATION BIOLOGY AT THE COLLEGE LEVEL, (2) NOTES ON COMMENTS BY RESOURCE PERSON, ROBERT GAGNE, ON THE OBJECTIVES OF COLLEGE GENERAL EDUCATION BIOLOGY, AND (3) DESCRIPTIONS OF TWO BEHAVIORALLY ORIENTED COLLEGE LEVEL GENERAL EDUCATION BIOLOGY COURSES FOR NONSCIENCE MAJORS. A BIBLIOGRAPHY OF NATIONAL SCIENCE TEACHERS ASSOCIATION PUBLICATIONS OF INTEREST TO COLLEGE SCIENCE TEACHERS IS INCLUDED. (DS)

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NATIONAL SCIENCE TEACHERS ASSOCIATION

WASHINGTON, D.C.

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STEPS TOWARD SCIENTIFIC LITERACY

A Report of College-Level Conferences

on Science for Nonscience Majors

1967-68

National Science Teachers Association

1201 16th Street, N.W., Washington, D.C. 20036

INTRODUCTION

During the 1967-68 academic year, the National Science Teachers Association sponsored four working conferences with teachers of college science who were concerned with teaching science for the nonscience major. Meetings were held at Wichita, Kansas, and Berkeley, California, in conjunction with NSTA Regional Conferences. Other meetings were held at Philadelphia, Pennsylvania, and Jacksonville, Florida.

Two aspects of science education for nonscience majors were emphasized at these meetings: 1) what is meant by the term "scientific literacy," and how important is it to produce college graduates who are literate in science, and 2) what are behavioral objectives and of what value are they in developing science programs? This report is a summary of some of the conclusions that have been drawn from the deliberations of these working groups.

It is obvious that these problems cannot be resolved in a single series of meetings. Their purpose was to delineate the scope of two of the problems that are facing college science teachers and to obtain some reaction from practicing classroom teachers concerning possible solutions and directions for further action. It is in this spirit that this report is sent to you. We hope that it may stimulate you to become involved in action that is developing in colleges to improve the quality of science education for nonscience majors.

A glance at the bibliography at the end of this report will show several other NSTA publications and published articles that are of interest to college science teachers. We urge your continued interest in college science teaching and invite you to participate in some of the ongoing activities. The NSTA Committee on College Activities is planning for such activities in the field of college science education. If you are not on the NSTA mailing list for college science teachers, you are invited to write for further information to: The Committee on College Activities, National Science Teachers Association, 1201 Sixteenth Street, N. W., Washington, D. C. 20036.

Persons who served on The Committee on College Activities during the 1967-68 academic years include:

Dr. Adrian Poitras, Chairman
Miami-Dade Junior College, Miami, Florida

Dr. Arnold A. Strassenburg
American Institute of Physics, New York City

Dr. Walter A. Schogoleff
State University of New York at Alfred

Dr. Herbert A. Smith
Colorado State University, Fort Collins

Dr. Jay Barton II
West Virginia University, Morgantown

Dr. Albert F. Eiss ex officio
National Science Teachers Association

ESTABLISHING GOALS FOR SCIENTIFIC LITERACY

A Conference Report
by
John E. Butler*

During the Fall of 1967 NSTA called a series of conferences on "Establishing Goals for Scientific Literacy", and to translate these into behavioral objectives that may be useful in the development of courses of study. Conferences were set up at Philadelphia, Pennsylvania, September 29 and 30; in Wichita, Kansas, October 13 and 14; in Berkeley, California, October 27-28, and a final invitational meeting in Jacksonville, Florida, November 17 and 18.

The stated purposes of the conferences were:

To consider the problem of scientific literacy as it is related to college science courses for students who are not science majors.

To define the categories of goals or objectives that are important for scientific literacy.

To suggest ways of expressing each type of objective in behavioral terms and to prepare a representative sequence of statements of behavioral objectives.

To suggest ways of evaluating the extent to which such objectives are achieved.

To suggest further action for expanding the lists of behavioral objectives.

The NSTA conferences on college science operated under the following assumptions:

The goals of scientific literacy and the goals of general education science for college students are so similar that differences need not be considered.

While scientific literacy is desirable for science majors as well as for others, the students' attitude toward science makes it essential to give special emphasis on scientific literacy for those who will take only one or two science courses during their college careers.

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Because behavioral objectives are stated more clearly and the terminal behavior is specified, course objectives are more likely to be achieved if they are expressed in behavioral terms.

Remarks stated or implied by the recorders from the various sections indicated those attending were filled with uncertainty and confusion as to what behavioral objectives were about and how they applied to their science courses. The major factor that prevented more progress from taking place was the fact few were aware of the literature and preliminary work already available in this area. At the conclusion of the conferences some went home convinced that it wouldn't work, while most were confident that there were beneficial effects from such an approach. Letters and comments from people traveling around the country indicate these conferences have caused many to ask questions concerning the performance of their students. Participants requested future sessions be longer with competent individuals (preferably behavioral science specialists) present to aid in developing behavioral objectives, the necessary tasks to accomplish these, and a criterion test to show that the student did in fact accomplish the stated objectives.

Individuals desiring to improve their courses need goals to give direction to their efforts. The Jacksonville summary group came to a general agreement that science courses or those aspects of courses designed for a liberal education have meaning only in the context of their humanistic and/or social awareness aspects. It follows that the first necessary step is a statement of what is meant by a scientifically literate individual. Paul DeHart Hurd in an article yet unpublished identifies some of these attributes we might expect of a scientifically literate individual after 10-15 years of science education beginning with kindergarten.

"What are some of the ways by which we can identify this person?

--He has faith in the logical processes of science and uses its modes of inquiry, but at the same time recognizes their limitations and the situations for which they are peculiarly appropriate.

--He enjoys science for the intellectual stimulus it provides, for the beauty of its explanations, the pleasure that comes from knowing, and the excitement stemming from discovery.

--He has more than a common sense understanding of the natural world.

--He appreciates the interaction of science and technology, recognizing that each reflects as well as stimulates the course of social and economic development, but he is aware that science and technology do not progress at equal rates.

--He is in intellectual possession of some of the major concepts, laws, and theories of several sciences.

--He understands that science is one but not the only way of viewing natural phenomena, and that even among the sciences there are rival points of view.

--He appreciates that knowledge is generated by people with a compelling desire to understand the natural world.

--He recognizes that knowledge in science grows, possibly without limit, and that knowledge of one generation engulfs, upsets, and complements all knowledge of the natural world before.

--He appreciates the essential lag between frontier research and the popular understanding of new achievements and the importance of narrowing this gap.

--He recognizes that the achievements of science and technology properly used are basic to the advancement of human welfare.

--He recognizes that the meaning of science depends as much on its inquiry process as on its conceptual patterns and theories.

--He understands the role of the scientific enterprise in society and appreciates the cultural conditions under which it thrives."

Dr. Hurd states--"These goals suggest the ends of a liberal education in the sciences, and there are undoubtedly other goals of importance; these statements are only suggestive. Education for an age of science must of necessity point in directions different from those of an agrarian society."

The Jacksonville summary group believes that if we are to achieve our goal of a scientifically literate individual, we must not neglect the affective domain. Attitudes, interests, values, appreciations and emotions can and should be included in the objectives of such courses. The consensus was that the objectives of science courses can and should be stated in behavioral terms. It was recognized that this is difficult in the cognitive area, but even more difficult in the affective domain. We saw no reason to back off because the task was difficult.

The frequently stated affective domain objectives were reviewed and in light of the above, the following were selected as being the most likely to be achieved through science.

ALL BRACKETED WORDS MUST BE DEFINED OPERATIONALLY*

IT SHOULD BE STATED THAT THESE MUST BE DEFINED FURTHER BEFORE THEY CAN BE CONSIDERED TO BE BEHAVORIAL OBJECTIVES

Awareness of Conditions:

1. (appreciates) the interaction of science and technology.
2. (recognizes) that science grows, possibly without limit.
3. (recognizes) that the achievements of science and technology properly used are basic to the advancement of human welfare.
4. (recognizes) that the meaning of science depends as much on its inquiry process as on its conceptual patterns and theories.

Acceptance of Values:

1. (rejection) of myths and superstitions
2. (the habit) of weighing evidence

Preference for values:

1. (Appreciate) the men who add to our storehouse of knowledge
2. (Willingness) to be convinced by evidence
3. The (value of) methods and procedures of science
4. Openmindedness
5. Curiosity

We take the point of view that an educated person in today's world of science and technology should be scientifically literate. Having accepted Dr. Hurd's points as a general base, the following are objectives which might be identifiable and/or measurable at the end of a course in science for non-science majors.

HOW DO YOU KNOW WHEN HE IS?

(a) The objectivity objective. The student (is objective) in his consideration of problems in that he evaluates information and sources of information (especially when there are conflicting scientific statements with social overtones).

(b) The relevant objective. The student (sees or searches) for the relevance of the content of the course to his personal and contemporary situation. ?

(c) The search for knowledge objective. The student seeks new personal knowledge and understanding. He voluntarily searches for information about scientific events and enterprises from any authoritative source; he can read intelligently about science in current non-professional literature.

(d) The inquiry objective. The student asks the kind of questions that indicates he understands the scientific approach in terms of the objectivity of evidence; he is willing to be convinced by evidence.

(e) The observational objective. The student is able (to observe) a dynamic system and (develop) a reasonable explanation for his observation.

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*At times I have used the exact words of recorders and inked in handwritten remarks to maintain as nearly as possible the wording of recorders and yet called attention to the need to use words that have a precise meaning.

(f) <u>The curiosity objective</u>. The student voluntarily observes and/or asks questions about:

(1) the scientific foundations and implications involved in the social problems

(2) the relevance of science to his personal and contemporary situation

(3) natural and technological phenomena

(4) the men who add to the storehouse of knowledge

(5) science as an inquiry process as well as sets of conceptual patterns and theories.

Discussion at most meetings centered around or brought out the following:

1. Behavioral objectives are used to:

(a) describe what the student will be able to do as a result of the instruction

(b) determine if a teaching job is successful

(c) improve communication with students

(d) develop criterion list questions, which might be used in evaluating the instructional program.

2. A behavioral objective describes a proposed change in the learner. The major problem here centered on the use or lack of use of precise action words.

3. Behavioral objectives must specify terminal behavior that is observable, measurable, and feasible.

4. They should be learner-centered. Successful terminal behavior is not achieved when the instructor has completed his presentation, BUT when the learner exhibits mastery of the objective by performance in terms of whether or not the person can demonstrate the tasks described by the objective.

5. Terminal behavior of one level is the entering behavior of the next level of a longitudinal structure.

6. That the terminal behavior is equal to the behavioral objective and is in turn equal to the criterion test. Many behavioral psychologists would say all must be created simultaneously.

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7. The real value of recognizing and being able to write behavioral objectives lies in

(a) selection of programmed materials for use in instructional programs.

(b) improvement of instruction (personally) as a result of recognition of behavior analysis as part of teaching-learning process.

8. Each college professor is not expected to--in fact, most likely will not-- write all the behavioral objectives for all the courses he teaches. However, he should be able to recognize the difference between behavioral objectives and platitudes which often pass for objectives. There are and should be a set of behavioral objectives from which a college teacher will be able to select the ones which suit his course, but the major contribution of these conferences lies not in the evolution of a set of behavioral objectives for a specific course, but rather in the personal growth in understanding of the important role behavioral objectives can play in college science instruction.

9. Faculty must design the course to include experiences which will enable the student to develop those behaviors and then to transfer them into new situations.

10. In the affective domain the behavioral objectives described must be developed in the context of some content, but the specific content to be included in such courses cannot be prescribed, because they can be developed from the cognitive domain of many science disciplines.

11. Most "natural science" teachers are not familiar with current research and theories in the behavioral and communication fields.

12. There are many science teachers who do not believe that their duties extend beyond the "pure science" of the cognitive domain.

During the discussions it was interesting to note that individuals who require reliable data to back up a scientific experiment do not require the same hard evidence in teaching. They recognize the variability of biological materials and populations and account for this in their research. In the classroom many of these same individuals do not use the same precise criteria for class instruction. They usually check their teaching efforts with a single test, not designed to see how much was learned, but to produce a curve, so that X number of individuals' names will appear on the Dean's list. No consideration is given to the possibility that some students may have known the subject before taking the course. For some, that course or segment of a course failed if it produced no change, however, the student may well appear on the Dean's list of scholars.

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In most sessions the first efforts of constructing even a very simple behavioral objective proved difficult and frustrating. At every session the frustrations were in a positive direction as shown by the behaviors of the participants. Most participants spent at least part of their Friday evening constructing behavioral objectives. In some cases a group would work until after midnight. In any event the Saturday sessions were quite different. Individuals were eager to test their work against a critical audience. The work could perhaps still be described as crude, but there was a quite different feeling in the air (to use a very non-behavioral term). One consultant made the statement that he had never seen a group come so far in only one and one-half days.

Each group had its own end product. The following are extracts from reports. The objectives, themselves, are not the most relevant nor in finished form. The objectives were usually parts of larger objectives but points that might be within the working sphere of those attending that session--ideas that a large group could work on.

One example might be the biology session at Wichita. At one point in the discussion they had arrived at the point where such statements as:

> "Describe the effects of certain waste products on the community. List factors in the environment that impinge on the individual."

They then got more specific and in the case of the one above--

> "Describe the effects of certain waste products on the aquatic environment. Given a list of items (or things or...) recognize those which are in a non-polluted condition."

At about this time a participant gave the following:

> "Given a town of stated size and location, the student will identify those factors which influence the sanitation system of the town."

The author of that objective pointed out that during the learning process Wichita might be the given town, while in a test situation San Francisco might be used.

An example of some of the give and take is shown below.

Original Objective	First Objection
List 4 ways in which the frog is uniquely adapted to its environment.	Is this a test question or an objective? Add a phrase showing it is an objective.
First Revision	**Second Objection**
The student will be able to list 4 ways in which a frog is uniquely adapted to its environment.	The ways in which a frog is adapted are not unique.

Second Revision

The student will be able to list 4 ways in which the frog is adapted to the environment.

There were further refinements, but this is to show the working pattern that evolved within this group.

One Physical Science group came forth with several goals with objectives. A few are:

Goal 1: Units of matter interact. Most interactions are caused by electromagnetic, gravitational, and nuclear forces.

Objectives:

a. To be able to construct a model demonstrating at least three types of molecular bonding.
b. Describe various forms of communication in terms of electromagnetic wave propagation.
c. Given experimental data, describe the forces of interaction as mass and/or distance varies.
d. Describe the interactions of the matter required for sustained nuclear chain reaction.
e. List at least five peace-time applications of nuclear reaction.

Goal 2: All interacting units of matter tend toward equilibrium states of minimum available energy.

Objectives:

a. Describe what happens to matter when two units react and reach an equilibrium state and explain why the reaction occurred.
b. List examples of situations in everyday life illustrating units of matter tending toward the equilibrium state.
c. Construct a model illustrating matter moving toward an equilibrium state.

Goal 3: One of the forms of energy is the motion of units of matter. Such motion is responsible for heat and temperature and for the states of matter: solids, liquids, gases, and plasma.

Objectives:

a. Classify the states of matter in terms of kinetic energy.
b. Distinguish between temperature and heat.
c. Given appropriate data construct a graph formulating the relationship between matter and energy.
d. Design an experiment to show that matter is conserved in a chemical reaction.
e. Test the hypothesis that osmotic pressure is proportional to the concentration of the solution.

f. Construct a 3-dimensional model of Brownian movement.

The Jacksonville summary sessions recognized that most of the goals we had identified were no longer the purview of science alone. Many are goals one would have expected from a similar conference in another discipline--for example, economics or anthropology. We also recognized that once the terminal objectives were identified, strategies for their implementation and evaluation worked out, we may discover that some can perhaps better be accomplished in areas other than where they now reside. This point was well made in a recent article by Dr. R. M. Morgan[1]. It was suspected by the group that solving this problem of vested interests may be more difficult in colleges than in the pre-college area.

With time running out at the one and a half day conference at Jacksonville, it was decided to concentrate on one problem in the affective domain with which some of the group was familiar, so we took as our departure one of the objectives of the Philadelphia conference. We used, "The student will perceive the philosophical problems involved in scientific application".

We agreed that one could only achieve this terminal task by possessing a substantial amount of underpinning. We next studied material developed by Dr. Edwin Kurtz for a general biology course at the University of Arizona. There were 56 objectives in all. These were primarily for pretest purposes to determine what the student brought to the course by demonstrable performance. By using Dr. Kurtz's materials we were able to construct one possible series of tasks that would lead to the terminal behavior. The primary task was that the student would be able to distinguish among units of length (meter, centimeter, millimeter, and micron), units of mass (kilogram, gram, milligram, microgram) and units of time (year, month, week, day, hour, minute, second, micro-second) and express one quantity in terms of the other.

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[1]Morgan, R. M. "The Science of Education: Research, Ideas and Needs" from The Science Teacher 34: 32-33, Nov. 1967.

The group recognized that many non-science students do not have these performances as a part of their background, but we arbitrarily stated that we would make the assumption that the student had achieved by prior experiences the necessary skills, processes, facts to do the following:

Given a set of measurements of a quantity or object, construct a bar graph of the frequency distribution of the measurements; performance of this task may require grouping of the measurements into modal intervals.

This led to--

Given the mean, mode, median, range, and frequency distribution of a set of measurements, describe in words the quantity or object being measured.

Which underpins--

Given a number of observations, tables of paired events, and graphs of paired events about a process, construct one or more models of the process.

Which leads to--

Given a model of a process, refine the model on the basis of new observations, inferences, and hypotheses.

And--

Given the models (two or more) of a process and the information upon which the models are based, compare the models and state the relative merits of each model.

At this point we developed the following bridging objective--

Given a series of problems which require various 'conflicting' models for the solutions of the problems, the student will choose the appropriate model for each of the problems without conflicting feelings that one of the models is 'right' and the others are 'wrong'.

Which was one path to reach our final goal--

The student will perceive philosophical problems involved in scientific applications.

The invitational group at Jacksonville were to summarize and produce recommendations. The group felt the initial meetings had shown that there was an interest in behavioral objectives and that further working group meetings needed to be held around the country. To be worth the time and money expended each working group must have present one or more behavioral psychologists who can ask the question to insure the participants are going in the right direction. The Jacksonville summary group felt that the reporter of the Biology section at Berkeley pointed this need out most clearly. Appendix A has exerpts from the report. Note the statements by Gagne, usually short probing questions.

To summarize, the group would point out that Behavioral Objectives can be a powerful tool in curriculum development. As with any tool it could be dangerous, if not properly used. In order to make the performance objectives operate, the laboratory becomes the center of focus-- not the lecture. This will pose real problems for those schools now teaching general education courses without a laboratory. MORE WORKING SESSIONS ARE NEEDED WITH THE HELP OF COMPETENT BEHAVIORAL PSYCHOLOGISTS OR OTHER KNOWLEDGEABLE HELP.

I would close this report with a summary statement by Albert Eiss, Associate Executive Secretary of NSTA, presented at the Philadelphia conference.

A Challenge for Change

The college teachers should show these behaviors in planning and teaching their courses.

1. Practice the values attributed to scientists

   curiosity patience persistence

   open-mindedness tolerance

2. Analyze the goals of the course(s) you are teaching by analyzing the tests on which grades are based.

3. Prepare a series of statements that define performance standards for students. Place these in the students' hands before class and lab sessions begin.

4. Base final grades on tests designed to evaluate these performance standards, and nothing more.

Remember, if you can't define the standards you are setting in specific terms, you can't claim to be teaching a fair course or even know yourself the goals of the course you are teaching. If you analyze your exams and derive from them the goals of your course, and are satisfied with this statement of goals, you are "on the beam".

APPENDIX A

David G. Barry, Chairman
San Jose State College, California

Jacqueline Dickinson, Recorder
Citrus College, Azusa, California

Robert M. Gagne, Resource person
University of California, Berkeley, California

. . . .

Thomas A. Steyaert, Diablo Valley College: For non-majors the biology course should interlock with other fields the student studies. For majors the courses should display sequential interlock.

Paul Geisert, Oak Park: What does the non-biology major do with his information?

Steyaert: It becomes part of his conversation with other teachers and family.

Dr. Barry: Biology is relevant to life of all persons.

________ : Yes, as caretakers of their environment e.g. an appreciation of outdoors, if created, will help protect natural resources.

Geisert: How will student act in this regard? What is the response of the knowledgeable student?

J. Fischer: Appreciation is sometimes a long-term phenomenon. No immediate change in behavior is visible.

Gagne: You must decide what you want the biology students to be able to do after taking the course.

Seven objectives stated (for elementary science courses) which apply to any course.

1. Student tends to apply scientific thought to a wide range of problems; can tell fact from fiction.

2. Acquires a knowledge of structure of disciplines he will encounter in advanced courses.

3. In written accounts he can identify the question, variables, hypotheses, data, results, and conclusions for what they are.

4. Can do the same with oral accounts.

5. Can make necessary inferences from incomplete accounts such as news reports.

6. Given a problem, he can design one or more experiments to test an hypothesis.

7. Appreciation and interest in subject is indicated by choice of related leisure time activities such as reading and entertainment.

Steyaert: A problem-solving responsibility and a self identity also should arise from the biology course.

Drapkin, Fullerton J.C.: Students should be given opportunities for making choices--even wrong choices. They learn a lot from failures in the lab.

Gagné: The point is how the student will act after instruction.

Fischer, Ventura College: Teachers should act in accord with theory. "How many here use bio-degradeable detergents, for example?"

Gagné: What do you expect specifically from the student?

Barry: Should define definite behavioral areas, e.g.
1. self identification
2. conservation

Geisert: Four objectives basic to all science courses include;

Process		Content	
understood	applied	understood	applied

courses usually	5% process;	95% content
BSCS - blue	50% process	50% content
	85% process	15% content more like it for some students.

Gagné: What convinces a teacher that his student has understood?

Barry: If he can behave with information he understands.

Gagné: Student is asked to define an hypothesis, he does so. Does this mean he really understands?

Barry: Is this behavior or simply response to a question? Independent behavior - observable behavior - is a better indication that he has understood.

Gagne: With a problem situation the problem is still set up by the professor.

Barry: Student should be separated from a question-answer situation in order to define behavior.

Drapkin, Fullerton J.C.: College lecturers have to throw information at students and ask them to throw it back; part of this involves process. Is this really process or information transfer?

Geisert: This is process understood but not applied. A miserable way to teach biology.

Brooks, San Diego State: What are labs for? An integrated experimental lab and lecture does away with objection raised by Geisert.

Young, San Jose State: Does this apply to one course or the works?

Geisert: Extension of points: Process understood entails lab activities, tools, techniques of biology. Student should be able to describe experimental processes used by scientists.

Process applied - one objective is to instruct in such a way that problems of life will be solved more efficiently.

Content understood - the biologically literate student will be able to integrate popular scientific literature.

Content applied - apply content to modify behavior; positive or negative behavior responses will result.

Mrs. Chew, Santa Monica City College: Planning for parenthood and leisure might apply here too.

Geisert: Yes,--e.g. the pill - content
Use of the pill - process

Process and content appreciated modifies behavior.

Young: Other commitments must be considered before attempting a given behavior response.

Drapkin: Doesn't content applied merge into process?

Geisert: It's a matter of degree and semantics.

D. Isaak, Pacific College: Likes Simpson's approach. Understanding itself leads to behavior.

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Geisert: Go from process to content when determining behavioral objectives.

Isaak: What process?

Chew: One can teach <u>any</u> related process.

Geisert: "Process is what the biologist <u>does</u>".

Barry: The idea here is not peculiar to science; data input is similar in other fields. The methods in history are similar; the evolution of data here is similar.

Gagne: The disciplines of science are in agreement regarding processes.

Godfrey: Ricks College: Can you teach content by process always? Theoretically, but not practically.

Drapkin: Did Gagne mean this? Process belongs to lab and content to lecture?

Gagne: Emphasis on process goes along with emphasis on lab.

Drapkin: Not necessarily so; cannot separate content and process; they always come across together. We could re-orient lectures to effect interaction that we might call process.

Geisert: Disagrees. Process can be taught in lecture.

Brookes: Demonstrations are generally more content than process. UCSD and USD don't differentiate between majors and non-majors curriculum-wise.

Isaak: Questions repetition involving teaching process.

Barry: Student should understand design and perform design in order to fulfill process.

Isaak: Will have to settle for less than 100% performance.

Chew: Difficulties with overcrowded classes brought up.

Geisert: Understanding with administration necessary here--otherwise course will be "The Facts of Biology".

Drapkin: We must adapt to the existing situation.

Godfrey: Baker and Allen, <u>Study of Biology</u> uses process at end of each chapter.

Drapkin: Too hard for some Fullerton Junior College students; should we adopt multi-textbook use?

The new texts, then, should teach process.

Godfrey: Suggest putting 10 topics under each heading.

Geisert: Could use 8 or 9 major themes from BSCS-blue to make 36 boxes. e.g. Cell Theory

Content understood	Content applied	Process understood	P.A.
List 24 parts of cell and define functions	More difficult	Use microscope and staining techniques	?

Nassau: McGraw-Hill Book Co., N.Y.: Doesn't appear that affective behaviors are being discussed; essentially cognitives have been considered.

As an affective behavior response--a student might decide on a career in science after taking a biology course.

Evidence for acquired appreciation of biology is necessary

Gagné: Two suggested -
1. Student would choose science-oriented activities during leisure time.
2. Student would accept the opinion of a scientist over that of a mystic or politician.

Fletcher: Student, U.C. Berkeley: Disagrees on taking word of a scientist. The student should look at data himself rather than taking anybody's word.

Fels: L.A. Trade Tech College: The student must relate biology to everyday life - this is easier with biology than with chemistry or some other fields.

The student might bring in newspaper articles--indicating affective behavior--(Required in Fels' course).

Nassau: Better indication of favorable behavior response if they brought articles from newspaper in on their own.

Smoking--knowledge not affecting behavior here.

Geisert: Advertisers know behavioral objectives better than biologists.

Barry: Alcohol and tobacco--pro values more important than con values to individuals.

Nassau: Knowledge does not necessarily have any affective change--we're interested in this.

Barry: Group appointed to specify themes and break them down under Geisert's headings.

Geisert, Brookes, Godfrey, Gagné, Dickinson, Isaak present. Discussion ensued.

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Dickinson: It is difficult with certain topics (to which students should be and are exposed) to go into a great deal of process. The understanding of techniques necessary here is beyond the grasp of non-biology majors taking a single course. For example, an understanding of process pertinent to Watson and Crick's theory on DNA structure involves knowledge of X-ray diffraction techniques and biochemical techniques beyond the scope of non-biology majors. It seems here that it is more practical to settle for content.

Discussion of breakdown on various themes followed, but limited time prevented the compilation of these specifics.

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NOTES ON COMMENTS OF ROBERT GAGNE
By Paul Geisert

First, it is necessary to recognize that there are two major categories of objectives applicable to college biology. On the one hand, the student must learn about <u>processes</u>, that is, what biologists do when they are being scientists. On the other, students need to learn certain facts and principles of biology, referred to as content, which in a historical sense has been generated with the use of scientific processes by other scientists, and which the student will in turn use in learning about processes in situations that are novel to him.

Generally speaking, the objectives of education in biology at the college level are that the student demonstrate capability in

(1) understanding processes,
(2) apply processes,
(3) understanding content, and
(4) applying content.

Understanding process. One objective of biology is to have students engage in laboratory activities, use the tools and techniques, think the thoughts, and in general engage in the same processes of science as the biologist. As a result, he should be able to:

(1) given an account of a scientific experiment, identify the scientific processes by which scientists arrived at their conclusions, describe these processes, demonstrate how the results were obtained, and state what conclusions can legitimately be drawn;

(2) given a problem which is capable of scientific investigation, describe the scientific processes necessary to achieve a solution.

Applying processes: One objective of biology is to instruct the student in the processes of science in such a manner that he will be able to approach the problems of life in a manner which will allow him to solve these problems more effectively than if he did not have biology. Such problems cover a broad range, both scientific and unscientific, but include particularly those of health, conservation of natural resources, and personal well-being. The student should be able to:

(1) make decisions concerning a wide range of biologies--social problems which are rationally derived from a balanced consideration of evidence;

(2) identify and search for missing portions of the application of scientific procedures to such problems, and demonstrate their application in arriving at solutions.

Understanding content. One objective of biology is to instruct the student in the content of biology in such a manner that he will be biologically literate. The student needs to learn a variety of previously established facts and principles in the general areas of: Evolution, Cell Theory, Genetic Continuity of Life, Diversity of Type and Unity of Pattern of Nature, Complementarity of Structure and Function, Intellectual History of Science, Homeostasis, and Biological Roots of Behavior, Complementarity of Organism and Environment; among others. Upon completion of the course, the student will be able to:

(1) Communicate to others the main ideas of current articles and and news reports on biological topics, as they appear in newspapers, periodicals, T.V., books, conversations, etc.:

(2) Demonstrate by showing or describing specific examples of each biological fact or the operation of a principle;

(3) Incorporate particular biological content into a description of a more elaborate abstraction, such as a generalization, hypothesis, or theory.

<u>Applying content</u>. One objective of biology is to instruct the student in the content of biology in such a manner that he will apply the content to modify his behavior in regard to the topic and its personal and social consequences. Taught the concept of disease transmission prevention, the student should behave in a manner that prevents transmission of disease. Taught the concept of vitamin action, the student should behave in a manner such that he will not have a vitamin deficiency, etc. In summary, the student should, when he completes the course:

Choose courses of action which exemplify the application of biological principles to the maintenance of health, and to the conservation of life--maintaining features of the natural environment.

<u>Science Values</u>

Certain kinds of values are expected also to be a part of education in biology. To a considerable extent, these are indicated by the choices made by the graduate, which constitute the basis on which his preferences, interests, and attitudes may be assessed.

<u>Appreciation of biological science</u>

It is assumed, if the student behaves in the manner described in the previous section, that he has an appreciation of science. The content and processes he has learned about are assumed to be of sufficient interest and importance to modify his behavior with regard to biological topics.

<u>Interest in scientific activities</u>

The student will manifest his interest in scientific activities by choices (indicating relative preferences) made in reading, entertainment, and other kinds of leisure-time pursuits.

<u>Valuing of scientifically derived evidence</u>

The student will question statements purporting to be "proven", and will demand verification of such statements by scientific procedures. His choice will be for evidence which is derived in accordance with the methods of science.

Biology 12: A Behaviorally Oriented Course for College Sophomores

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Biology 12 is a one semester, 3-unit course especially for majors in elementary education. It is scheduled for two lectures and one laboratory per week for fifteen weeks. Similar courses in physics and chemistry are prerequisite to it. Enrollment is approximately 150 students each semester.

Based upon experiments with this course during the past three years, this course is now designed along behavioral lines and all instruction is individualized. The course now consists of 74 behavioral objectives which have been sequenced psychologically into a behavioral hierarchy. All objectives are stated in terms of observable student performance. During the first week of instruction each student is given a diagnostic measure of his science competencies as described by the 74 objectives. Each of the 150 students is then provided a unit of instruction, the decision as to which unit of instruction to prescribe for each student being based on the performance of that student on the diagnostic measure. Each unit of instruction consists of a list of objectives for that unit, a diagram of that portion of the hierarchy which pertains to it, sample items for self-appraisal by the student of attainment of the behavioral objectives, a description of instructional activities, and suggested references for additional study. Each student is told that when he can perform the self-appraisal items for a unit of instruction, he is to ask the instructor for a competency measure for that unit. A competency measure is then administered and, if the tasks are performed acceptably, the student's hierarchy chart is appropriately checked and a unit of instruction for the next higher tasks is prescribed. If a student performs unacceptably on a competency measure, he may re-take a similar measure at a later time without penalty. No new instruction is prescribed until performance is acceptable.

In this way each student proceeds at his own rate, instruction is individualized, immediate assessment (and usually positive reward) is given for each quiz or competency measure, each student knows what is expected of him at all times, and each student knows of his own progress at all times. Although students report to an office-laboratory in which other students may be working on as many as 25 different units of instruction, there are no formal lectures or laboratories. Approximately 90 percent of the students progress rapidly and with little or no instruction other than the activities described in the units of instruction.

A posttest of science competencies for Biology 12 will be administered at the end of the course for assessment of retention of behaviors acquired throughout the course. Data obtained throughout the semester will be used to test the validity of the behavioral hierarchy, to correlate student success and rate of achievement with student attitude, and to revise the instructional units and competency measures.

Biology 102 - A Behaviorally Oriented Course

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The general education biology course for non-science majors at Miami-Dade Junior College (North) has been completely revised for Fall, 1968, and will, as a result, encompass three unusual characteristics. First, because of the total enrollment (about 4,000 annually), limitations of instructional staff and facilities make it impossible to offer students a laboratory experience; second, all students receive one hour of instruction per week in a large auditorium which utilizes a specially prepared audio-visual presentation; and, third, goals and objectives are stated in behavioral terms.

The course, which is a one-semester course, consists of fifteen units, one unit for each of the fifteen weeks of the trimester. Each week's work then is a more or less self-sufficient unit. Each unit is concerned with a major topic or concept such as "The Cell", "Energy Relations", etc. The three class hours each week are scheduled beginning with an introductory lecture/discussion during the first hour, the auditorium presentation during the second hour, and a question-answer discussion during the third hour. Instructors follow a departmental syllabus, but have considerable freedom in their selection of the examples used to illustrate the concepts and principles being emphasized. Departmental mid-term and final examinations are utilized.

The ultimate goal of this course is to develop students who are scientifically literate insofar as biology is concerned. The course objectives are stated in behavioral terms and are twelve in number. Course objectives, for the most part, are in the Affective Domain and include such goals as: "He utilizes the logical processes of science, recognizes their limitations and the situations for which they are peculiarly appropriate".

Each Unit, in turn, is initiated with a syllabus listing of the "operational" objectives for that unit. These behavioral objectives lie in the Cognitive Domain and this list includes such objectives as: "A successful BIO 102 student will be able to: (1) List and define the steps of the scientific method and state reasons why it is used, (2) Prepare a list of twenty different roles that various plants play in providing a suitable habitat for man and other terrestrial animals," etc. There are from five to thirteen behavioral objectives, such as those cited above, for each unit; a total of one hundred and twenty-four objectives for the course.

Test items reflecting the behavioral objectives of each unit have been constructed and these will be used in assembling the departmental examinations. The course goals previously referred to reflect terminal behaviors that cannot be tested by conventional testing techniques since they include, generally, such behavioral patterns as attitudes and interests. Pilot sections of this "new" course have indicated that the total program is workable and capable of success.

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* Copies available (free if no price is listed) from the National Science Teachers Association, 1201 Sixteenth Street, N. W., Washington, D. C. 20036. Orders of $2 or less must be prepaid.