DESIGNING SCIENCE UNITS OF STUDY

Marlow Ediger

Rt 2. Box 38, Kirksville
M063501, U.S.A.

To design the curriculum area of science, careful attention needs to be given to the structure of unit planning. The objectives for students to attain may be stated in measurable terms. To achieve balance in the curriculum, cognite, affective and psychomotor ends need to be stated with precision. Each domain of objectives is salient for student attainment. After instruction, it is possible to measure if a learner has or has not achieved the measurably stated objective.

Toward the other end of the continuum, general objectives may be stated and implemented in ongoing units of study. To stress balance among general objectives, understandings, skills and attitudinal goals should be emphasised in teaching-learning situations. With general objectives, it is not possible to measure if a student has or has not achieved the chosen end. However, flexibility in curriculum development may be emphasised, such as student-teacher planning.

The measurably-stated objectives versus general objectives debate represents differences in assumptions and beliefs in education. The measurable objectives movement stresses:

1. What has been learned is observable and measurable.
2. Certainty needs to be in evidence in terms of what a teacher is to teach and students are to learn. Uncertainty of which cognitive, affective, and psychomotor objectives (specificity of ends) to stress in lessons and units represents teachers who waver and are uncertain of themselves.
3. The importance of learning routes or activities which must harmonise directly with the chosen ends.
4. Validity in testing. Items on a test must match the objectives emphasised in teaching-learning situations.

General objectives advocates believe:

1. Important learnings, be it subject matter skills or attitudes cannot be measured with precision.
2. An adequate number of goals should come from teacher-student planning of the curriculum.
3. Individual students may well pursue goals different from other learners. Common goals for all to attain then is not possible.
4. An open-ended curriculum needs to be in evidence which meets student's interests, purposes and needs. General objectives can make provisions for individual differences among learners.

The debate between measurably stated and general objectives might be harmonised in utilising the former where feasible and possible and the latter whereby students with teacher assistance develop goals, learning opportunities and appraisal procedures.

The writer recommends the following for science teachers in the measurably stated versus general objectives debate:

1. Teachers individually need to be highly knowledgeable pertaining to assumptions involved in each of the two kinds of objectives.
2. Both measurable and general objectives need to be implemented in the science curriculum.
3. Science teachers need to appraise how specific and general objectives affect student progress in on-going lessons and units.
4. Each teacher needs to analyse the quality of teaching being emphasised when contrasting the utilisation of measurably stated versus general objectives. Under which conditions does the teacher of science believe that learners can achieve in a more optimal manner?
5. Curricular constraints need to be taken into developing the science curriculum. Does a state mandate Criterion Referenced Tests (CRTs) with tile utilisation of measurably-stated ends to ascertain learner progress in science?
6. The ultimate statement in the teaching of science pertains to helping each student achieve as much as possible in each lesson and unit of study.

Philosophies of Science Education

Diverse philosophical schools of thought in science are in evidence to develop and implement lessons and units in science.

Experimentalism emphasises the use of problem solving experiences for students. Flexible steps in problem solving involve:

1. Identifying the problem.
2. Gathering data to solve the identified problem.
3. Developing a hypothesis directly based on the obtained data and in answer to the problem.
4. Testing the hypothesis.
5. Revising the hypothesis, if evidence warrants.

Experimentalism emphasises that real life problems be identified by students. The problems then come from society. In society, earthquakes, hurricanes, tornadoes, volcanic eruptions, among many other natural phenomena, occur. Out of these scenes and situations, problems arise and are identified, such as "What makes for the happening of earthquakes?" Information then needs to be gathered to answer the problem or question. An answer, tentative in nature, is then developed. The answer, a hypothesis, is then checked against further content, secured from a variety of reference sources. Modification of the original answer or hypothesis may then be needed.

Idealism, as a philosophy of education, emphasises in idea-centered curriculum. Science then becomes a part of the general education programme. A subject-centred, not an activity-centred philosophy, is then in evidence. Diverse academic disciplines, such as zoology, botany, physics, astronomy, biology, chemistry and geology provide subject matter for on-going units of study. Textbooks, workbooks, worksheets and a few selected audio-visual aids provide content to students. Universal ideas or generalisations in science units need to be achieved by students. The teacher needs to be a true academician and scholar to stimulate student learning.

Realism, as a third philosophy of education, advocates the utilisation of precise, measurable objectives. Realists believe that the real world of science can be known in whole or part as it truly is. What students achieve in each science unit can be measured. The real world of natural phenomena can then be stated in precise, measurable objectives. A variety of concrete learning activities, in particular, should be provided for students to attain the specific ends. Semi-concrete as well as abstract activities also should be in the offing. After instruction, it is observable and measurable if an objective has been achieved by students.

Existentialism, as a fourth philosophy of education, emphasises the learner, himself or herself, being heavily involved in deciding *what* (the objectives) to learn, as well as the *means* (learning activities) in on-going science units of study. Thus, a learning centres philosophy may be emphasised. More centres and tasks for learners to pursue are in evidence than what can be completed. Each student may then sequentially choose which tasks to complete, as well as which to omit. Students individually are involved in making these decisions. The teacher develops the centres for learner interaction. Better yet, student-teacher planning may be used to develop the centres and their inherent tasks.

When looking at the diverse philosophies of education and their implementation for the science curriculum, the writer recommends the following:

1. Each teacher needs to become thoroughly familiar with each philosophical school of thought.
2. Each philosophy needs to be implemented on a trial basis in on-going lessons and units.
3. The effect of the diverse philosophies needs to be observed in terms of student progress in science.
4. The science teacher needs to appraise the self as to how each philosophical strand affects one's own teaching style.
5. Teachers individually need to develop their very own philosophy of teaching science. The adopted philosophy must harmonise with students learning styles and one's own beliefs about learners and the actual act of teaching.

Processes versus Products

Science educators tend to disagree as to which is more significant in the curriculum—the processes or the products of learning. The American Association for the Advancement of Science (AAAS) in Science: A Process Approach (SAPA) emphasises in the programme of units of instruction that students achieve the following processes:

1. Observing
2. Recognising and using number relations
3. Measuring

4. Recognising and using space-time relations
5. Classifying
6. Communicating
7. Inferring
8. Predicting
9. Defining operationally
10. Formulating hypothesis
11. Interpreting data
12. Controlling variables
13. Experimenting

The above-named processes can be utilised in any academic discipline in science. With quality processes emphasised in teaching-learning situations, students in science lessons and units should attain vital, relevant subject matter. However, emphasis in the AAAS SAPA programme, processes are more important than products, that is subject matter learnings acquired by learners.

Other science educators advocate products (vital facts, concepts and generalisations) as being the major outcomes of teaching-learning situations. Thus, from the academic disciplines involving zoology, botany, biology, astronomy, chemistry, physics and geology, students should acquire structural ideas as well as significant concepts and facts.

The writer recommends that:

1. Processes and products receive equivalent emphasis. With quality processes stressed in science, worthwhile facts, concepts and generalisations should follow as end results.
2. Each teacher should be highly knowledgeable about diverse process and product goals in teaching science.
3. Objectives in the science curriculum reflect an adequate number of processes as well as products.
4. Learning opportunities to guide students to attain process ends as well as product goals should be inherent in each on-going lesson and unit.
5. Evaluation procedures need to emphasise processes and products in the science curriculum. A variety of appraisal procedures should be utilised, such as teacher observation, student self-evaluation, teacher written tests as well as standardised tests.

A Logical versus a Psychological Curriculum

Who should sequence or order objectives and learning experiences for students to pursue? The science teacher, a team of teachers and/or State-mandated Criterion Referenced Tests (CRT) may determine sequence in attaining objectives in science. These educators then base the order of learning for students on logic or rational thought.

Toward the other end of the continuum is a psychological science curriculum. A learning centred psychology may well be emphasised here. An adequate number of centres needs to be in evidence. At each centre, five or six different tasks should be available. Enough centres and tasks should prevail so that students may truly select what to pursue and complete, as well as what to omit. Interest, purpose and meaning need to be in evidence for each learning activity pursued. The teacher develops the centres and tasks. Teacher-student planning can also be in evidence at the diverse centres with its inherent tasks. In a psychological science curriculum, each student selects sequential tasks within a flexible framework.

In viewing the logical versus psychological science curriculum, the writer recommends that:

1. Each student needs to achieve optimally regardless of which psychology is utilised.
2. The best order or sequence in learning needs to be in evidence for students individually.
3. New ways of developing sequence need to be sought and tested in actual teaching-learning situations.
4. Experimental studies need to be conducted to determine under which sequential plan—a logical, a psychological or a combination of the two approaches—is best for guiding students on an individual basis to achieve as much as possible.
5. Teachers should focus on the concept of sequence when implementing on-going lessons and units.

Scope in the Science Curriculum

What should be the breadth of knowledge, abilities or attitudes emphasised in science instruction? Each of these categories of objectives should receive adequate attention. Numerous ways are in evidence to determine scope.

First of all, problem solving can be emphasised in a quality science curriculum. The problems should be real and life-like. Students need to perceive purpose and meaning within the problems identified. Thus, from current events items, the following come up repeatedly:

1. What causes rain, dew, frost, snow, and hail to occur?
2. What causes mountains to form?

A variety of reference sources need utilisation to secure reliable information in answer to the identified problems. Testing and revising of answers is a definite possibility. A quality science curriculum in stressing scope might then emphasise problem solving.

A second approach in achieving scope would be to utilise basal textbooks, single or multiple series, together with workbooks and worksheets. The table of contents of the basal series will indicate which units are to be emphasised. The writer would thoroughly recommend if textbook contents determine scope in the science curriculum that an adequate number of audio-visual materials be utilised to clarify ideas presented from the reading materials.

A third approach in determining scope in the science curriculum is to emphasise teacher-student planning. Within each science unit, the teacher can stimulate students to plan definite goals, learning opportunities and appraisal procedures. Students are encouraged, not hindered, to participate in developing the science curriculum.

A fourth method of scope emphasises project methods of instruction. The late William Heard Kilpatrick (1871-1964), Professor at Columbia University in New York City, advocated flexible steps to follow in the project method. In the project method, Dr. Kilpatrick recommended open-ended flexible procedures. First of all, the student needs to perceive purpose or reasons for the project. Next, the learner with the teacher plan the project, as established in the purpose. After the planning has been completed, the student guided by the teacher carries out the plan. Once the project has been completed, its quality needs to be evaluated in terms of desirable standards. The total number of projects, successfully completed by students, would pertain to the *scope* of the science curriculum.

There are numerous approaches available in determining scope in the curriculum. When using problem-solving procedures, the textbook method, student-teacher planning, and/or the project method, provision needs to be made for fast, average and slow learners. The writer recommends the following in achieving a desirable scope in the curriculum:

1. Use diverse, not a single procedure. Students like variety of methodology in teaching and learning.
2. Determine under which conditions students achieve more optimally. A carefully developed research design could emphasise quality practical research in the curriculum.
3. Study other methods of determining scope in science. Scope should not remain static, but be subject to modification and change to provide more adequately for each individual student.
4. Use the carefully selected basal textbook as the core in determining scope. Have problem-solving, student-teacher planning and the project method elaborate on textbook subject matter.

In Summary

The writer has identified numerous issues in teaching science. These issues include

1. Specific versus general objectives in teaching.
2. Diverse schools of thought in the philosophy of education.
3. Process versus product ends of instruction.
4. A logical versus a psychological sequence.
5. Numerous different means in determining scope in the science curriculum.

Methods of teaching science need to incorporate ways to resolve the above identified issues. The ultimate goal of teaching science is to assist each student to attain as much as possible in the science curriculum.

References

ABRUSCATO, JOSEPH. 1982. *Teaching Children Science.* Englewood Cliffs, Prentice Hall, Inc., New Jersey.

BEANE, JAMES A., et. al. 1986. *Curriculum Planning and Development.* Allyn and Bacon, Inc., Boston.

CARIN, ARTHUR, and B. SUND. ROBERT. 1985.*Teaching Science Through Discovery.* Charles E. Merrill Publishing Company, Columbus, Ohio.

GEGA, PETER C.1986. *Science in Elementary Education.* Fifth edition. Macmillan Publishing Company, New York.

HENSON, KENNETH T. and DELMAR JANKE. 1984. *Elementary Science Methods.* McGraw-Hill Book Company, New York.

JACOBSON, WILLARD J. and ABBY BARRY BERGMAN. 1980. *Science for Children: A Book for Teachers.* Englewood Cliffs, Prentice Hall, Inc., New Jersey.

MOORE, W. EDGAR, et. al. 1985.*Creative and Critical Thinking.* Houghton Mifflin Company, Boston.

TROJCAK, DORIS A. 1979. *Science with Children.* McGraw Hill Book Company, New York.

VICTOR, EDWARD. 1985. *Science for the Elementary School.* Fifth edition. MacMillan Publishing Company, New York.