Column Editor: James Raths

Acquisition of Elementary Science Behavior by Children of Disadvantaged Families

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THE experimental elementary science program, *Science—A Process Approach*, developed by the Commission on Science Education of the American Association for the Advancement of Science, has endeavored to develop a sequence of instructional materials which are applicable for the entire elementary school population of children. The instructional materials are intended for use in all geographic regions of the United States, for children in kindergarten through grade six, within a variety of population centers including rural, suburban, and urban, and with a wide range of social and economic backgrounds encountered in these environments.

Some curriculum theorists would argue that the development of such a curriculum is both idealistic and unrealizable. Whether it is possible to construct a curriculum with the universality desired is a function of whether the stated objectives of the curriculum are achieved by members of the population of intended learners. It is not a question which can be resolved by spectator analysis; some observable demonstration must be made.

Suppose the principal concern of the curriculum is to aid the learner in the acquisition of certain observable behaviors. Further, suppose that these behaviors can be ordered in a sequential manner which supplies a learning advantage to those trying to acquire the behaviors. Finally, assume that the instructional activities associated with the acquisition of each behavior are so constituted as not to depend upon peripheral experiences. That is, construct the instructional activities so that the child from a less advantaged background will not begin with a substantial learning deficit. The developers of *Science—A Process Approach* have, from the inception of their work, been committed to just these assumptions.

The model described by Gagne (1, 2) has been the basis upon which the instructional materials have been structured. The assessment model described by Walbesser (3, 4) has been the basis

upon which the curriculum has been evaluated. At the beginning of each exercise a set of behavioral objectives is specified. The objectives describe the behaviors which are expected to be acquired by the children during the activities. An exercise is composed of a collection of activities which can be completed within approximately one week assuming that there is science instruction each day of the week.

A second consideration in curriculum design is the subject matter to be included. Educational theorists (5, 6) have suggested the need for young children to handle materials which are part of their environment. Differing ideas with respect to the need for elementary children to deal exclusively with materials which are part of their environment, however, have been propounded by various authors including Preston (7) and Bruner (8). The developers of *Science—A Process Approach* did not limit themselves exclusively to either of these approaches—machines and biological systems are used, but so is the learner's everyday environment. The criteria used for determining what is included in the material is the set of behavioral objectives toward which the instructional materials are directed. Content deemed appropriate for conveying the objectives was the primary concern. The actual subject matter selected played a secondary role.

Particular subject matter was chosen because it held the best potential for facilitating the acquisition of the stated behavior. Material which would permit the involvement of the student in varied types of manipulations was actively sought. The manipulations might involve guinea pigs with which the stu-

dents could conduct tests of the animals' ability to run mazes. On another occasion children could identify two-dimensional projections of three-dimensional objects by manipulating objects such as cubes and spheres in a path of light and observing the shadows which they cast. After the children identify the need for classification systems to order their own belongings, they could proceed to make use of the common objects and living things in an aquarium to devise their own classification system.

What format should the materials assume? If the instructional activities are to be suitable for use by all children, then certain restrictions are immediately imposed upon the design. Under more restrictive circumstances, teachers are able to hand each child a book with printed symbols and pictures which constitute the essential sequence of instruction, and expect learning to occur through the interaction of the child with the book. This is not to be the case with *Science—A Process Approach*: no reading material is produced for the children's use for any of the primary grades, and only limited quantity is made available for the intermediate grades.

Children from advantaged backgrounds typically have higher reading achievement scores when compared with national norms than do those from less advantaged situations (9, 10). The elimination of reading material might very well serve to depress the difference between children for advantaged and disadvantaged groups. The instructional materials are in written form for the teacher together with kits of equipment for manipulation by the children. The same materials for *Science—A Process Approach* and instructions were used in every experimental tryout center. Hence, the conditions of instruction which could be held constant, descriptions of instructional activities, equipment, and financial support were controlled.

How did the students from the different socioeconomic levels perform on the assessment tasks given them? Was there any difference between the acquisition of behaviors for the children from the different areas? Were the behaviors described in any of the processes more readily acquired by any of the groups than by the others? This report deals with the data collected by the *Science—A Process Approach* staff which attempts to answer these questions.

A Structured Evaluation Program

In order to obtain the answers to some of these questions, a structured and defined evaluation program was considered to be an essential part of the curriculum development. At the termination of each exercise a sample of three children randomly chosen from the class was assessed by means of a competency measure. Each competency measure was composed of one task for each of the behavioral objectives described at the beginning of the exercise. The three children were presented the tasks on an individual basis and the teacher was asked to score them according to a key which was sent to her.

The responses for each task were scored on a binary scale, either acceptable or unacceptable. The scores were then sent to the project staff headquarters. The purpose of these data was to identify those parts of the instructional materials which did not succeed (the learners did not acquire the specific be-

haviors). Notice the assumption allied with this evaluation position: if the learners acquire the stated behaviors, then they are successful; if the learners do not acquire the stated behaviors, then the instructional materials are at fault.

From the beginning of the project an interest had been demonstrated in the suitability of the materials for different socioeconomic areas. This factor was taken into consideration when the tryout centers were originally selected. The data in this article are based upon results from fourteen tryout centers. The centers were: Tucson, Arizona; Berkeley and Palo Alto, California; Kern County, California; Tallahassee, Florida; Glencoe and the University of Chicago Laboratory Schools, Illinois; Monmouth, Illinois; Baltimore, Maryland; Ithaca, New York; Manhasset and Pelham, New York; Eugene and Portland, Oregon; Philadelphia, Pennsylvania; Austin, Texas; Seattle, Washington; and Oshkosh, Wisconsin.

The classes within these centers were classified into three socioeconomic categories. The A group represents the advantaged student population with median parent incomes of $20,000 and a median parent education of two years of college. The D group represents the disadvantaged student population with median parent incomes of $3,500 and median parent education of eight years of elementary education. The M group represents approximately the middle 25 percent income group of the student population sampled.

The hypothesis with which this investigation is concerned is the following: If behavioral objectives are stated, instructional activities written for guiding the teacher based upon the stated objectives, and behavioral hierarchies constructed from the stated objectives, then the percentage acquisition of the stated behaviors by the learners will be the same for all socioeconomic levels. Equivalent percentage acquisition is defined to be within four percentage points. Tables 1 and 2 present the results obtained for each of the parts summarized in terms of the simple and integrated processes. The number of exercises within each process in the part are identified by the frequency column, labeled *f*. The test of the hypothesis is presented in two parts. First the results of the disadvantaged and advantaged groups are compared with respect to the hypothesis being accepted (A) or rejected (R). This is recorded in the A and D columns. The second set of results compares the disadvantaged with the middle groups, the D and M columns. A summary of results for each process is presented in the section labeled *Total*. The A, D, and M classifications refer to the three socioeconomic groups defined earlier.

The data in Tables 1 and 2 are interpreted as support for the hypothesis.

Although the data do support the hypothesis, it should also be observed that the advantaged and middle income groups do show greater percentage acquisition on a larger proportion of the exercises than do the disadvantaged. *The disadvantaged group is successful.* In fact, among this group more of the children demonstrated acquisition of a larger percentage of behaviors in 14 of the 33 exercises in Parts One through Four for the Simple Processes than did children from the other two groups.

Is there any process in which the stu-

Simple Processes	One					Two					Three					Four					Five					Total				
	f	D & A		D & M		f	D & A		D & M		f	D & A		D & M		f	D & A		D & M		f	D & A		D & M		f	D & A		D & M	
		A	R	A	R		A	R	A	R		A	R	A	R		A	R	A	R		A	R	A	R			A	R	A	R
Classifying	3	3	0	3	0	3	3	0	3	0	2	0	2	0	2	3	3	0	3	0	2	2	0	2	0	13	11	2	11	2
Communicating	1	1	0	1	0	4	2	2	4	0	3	1	2	3	0	4	3	1	4	0	1	0	1	1	0	13	7	6	13	0
Inferring	–	–	–	–	–	–	–	–	–	–	3	2	1	3	0	4	4	0	4	0	2	2	0	2	0	9	8	1	9	0
Measuring	2	2	0	2	0	5	5	0	5	0	6	3	3	6	0	2	2	0	2	0	3	3	0	3	0	18	15	3	18	0
Numbers	2	1	1	2	0	3	3	0	3	0	4	3	1	4	0	3	3	0	3	0	3	3	0	3	0	15	13	2	15	0
Observing	10	10	0	8	2	5	5	0	5	0	3	3	0	2	1	4	4	0	4	0	–	–	–	–	–	22	22	0	19	3
Predicting	–	–	–	–	–	–	–	–	–	–	2	2	0	2	0	3	3	0	3	0	1	1	0	1	0	6	6	0	6	0
Space/Time	6	5	1	6	0	6	6	0	6	0	3	3	0	3	0	3	3	0	3	0	–	–	–	–	–	18	17	1	18	0

Table 1. Frequency of Acceptance and Rejection of the Hypothesis of Equivalent Acquisition for all Simple Process Behaviors in Parts One through Five of the Third Experimental Edition of *Science—A Process Approach*

Integrated Processes	Five					Six					Seven					Total				
	f	D & A		D & M		f	D & A		D & M		f	D & A		D & M		f	D & A		D & M	
		A	R	A	R		A	R	A	R		A	R	A	R		A	R	A	R
Controlling Variables	7	7	0	7	0	5	5	0	5	0	3	2	1	2	1	15	14	1	14	1
Defining Operationally	2	2	0	2	0	3	3	0	3	0	4	3	1	3	1	9	8	1	8	1
Experimenting	1	1	0	1	0	1	1	0	1	0	6	6	0	4	2	8	8	0	6	2
Formulating Hypotheses	1	1	0	1	0	3	2	1	3	0	3	3	0	2	1	7	6	1	6	1
Interpreting Data	3	3	0	3	0	11	9	2	10	1	5	3	2	5	0	19	15	4	18	1

Table 2. Frequency of Acceptance and Rejection of the Hypothesis of Equivalent Acquisition for all Integrated Process Behaviors in Parts Five through Seven of the Third Experimental Edition of *Science—A Process Approach*

dents from disadvantaged families demonstrate a high level of performance acquisition consistently? The data suggest two possible candidates. There is some indication that the disadvantaged group is more successful in the processes

of Observing and Classifying. They do not evidence as great a success in either the Numbers or the Communicating processes. These data may reflect the fact that the exercises in those processes deal with activities which may have been encountered by the more advantaged groups in their out-of-school environment.

It is probable that the more advantaged group will have been exposed to a richer and more diverse descriptive vocabulary. It is also possible that the probability of their having encountered graphs at other times is higher than it is for those children coming from lower socioeconomic backgrounds. Both of these behaviors are needed and used in the communicating sequence of activities. Perhaps the emphasis upon student performances on an active participating level contributes to the performance results of the students from the disadvantaged population group in the Observing and Classifying processes.

There appears to be one difference which may be significant between the performances of the various groups. In order to acquire the behaviors, the classes composed of students from the disadvantaged groups did not complete as many exercises during the year as did those students in classes from the other groups.

The median number of exercises completed per part was 20 in the advantaged group with a low of 18 and a high of 23; 18 in the middle group with a low of 15 and a high of 20; and 16 in the disadvantaged groups did not complete and a high of 17.

It certainly seems well worth this slightly slower progression through the instructional materials to gain the level of performance demonstrated by the competency measure data. In fact, this can surely be related to the adaptability of the instructional materials: providing the sequence of dependencies is retained, the rate at which individuals or classes progress through the materials is of less consequence.

In summary, the data support the hypothesis that it is possible to create a set of instructional materials that can be successfully used with a wide range of the elementary school population. It does appear that the level of verbal ability influences the level of behavior acquisition within certain processes. As the instructional materials are currently presented, there are some behaviors for which the children from the disadvantaged population are less facile. Further study might include the effect of long-term use of these materials on the behavioral acquisition of the disadvantaged population. The correlation of other variables such as previous science experience, the type of physical plant, the instructional materials being used in other parts of the curriculum, and the instructional conditions employed by the teacher appear to hold promise as variables that might help to account for the variance in performance.

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