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ABSTRACT

An overview and rationale for the Science Curriculum for Individualized Learning (SCIL) are provided. SCIL is the result of the individualization of the SCIS program. The SCIL management system is based on the exploration, invention, and discovery concepts of Piagetian theory. An evaluation study of two SCIL units, Interactions and Systems and Subsystems and Variables is presented. It was found that over 90 percent of the SCIL students in grades 3-6 achieved cognitive goals as measured by completed discovery lessons. Students in the SCIL program chose more positive responses when compared to students in teacher-made traditional curriculum. The SCIL students also chose more positive responses when compared with nonindividualized programs. Third grade SCIL study chose more positive response than did SCIL students in grades, 4, 5, and 6 suggesting that the units were well suited for the third grade students' developmental level. The parents of SCIL students chose highly positive responses when asked their perceptions of their children in relation to SCIL and science activities. (Author)

28.06

COGNITIVE AND AFFECTIVE OUTCOMES IN CHILDREN AS A FUNCTION OF PARTICIPATION IN SCIL, AN INDIVIDUALIZED VERSION OF THE SCIS PROGRAM

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INTRODUCTION

This paper is composed of two major sections. The first section includes a description of SCIL as an individualized approach to science instruction based on an already developed program, SCIS. The SCIL and SCIS programs are compared in terms of their structure. SCIL differs from SCIS in that it provides for learner differences. SCIL is based on Piagetian developmental concepts and the particular concept is keyed to an appropriate level of development. Freedom of choice and varied learning experiences are available for the SCIL students.

The second section is an evaluation study of the cognitive and affective outcomes as a function of participation in SCIL. Special definitions pertaining to the evaluation are offered. The instruments used and their qualities are explained. Findings are the comparisons between individualization and group instruction SCIL and two other programs (SCIS and Traditional) and SCIL and SCIS versus traditional, content differences.

SCIENCE CURRICULUM FOR INDIVIDUALIZED LEARNING:

AN OVERVIEW

e Science Curriculum for Individualized Learning (SCIL) is a proje undertaken by Research for Better Schools, Inc., Philadelphia, which attempts to individualize a particular science program and to implement the individualized version of this program in the schools.

RATIONALE

As a preface, a brief rationale for the use of an existing science program should be described. Each existing science program has a distinct philosophy and content organization; all are reasonably successful; each has taken approximately ten years to develop at a substantial cost. In addition, activities have been developed; materials are available in packaged sets; content has been organized n some logical manner; the program has been tested in the field; and the scientific knowledge is, for the most part, accurate. It would be wise, indeed, not to ignore this reservoir of material and experience.

As a result of an in-depth study of existing elementary science programs, the Science Curriculum Improvement Study, or SCIS, program was selected as best suited for adaptation to an individualized mode and was, therefore, chosen as the most feasible program to individualize. The individualized version of SCIS is entitled, "Science Curriculum for Individualized Learning," or "SCIL." The conceptual framework and teaching strategies formulated by Karplus and Thier over the past ten years for SCIS are a blend of recent advances in both science and learning theory. The SCIL program takes advantage of this developmental effort by basing its conceptual framework and teaching strategies on SCIS.

In addition to looking at the substantive structure of SCIS a little differently (in a hierarchical arrangement) the SCIL program attempts to enhance SCIS by providing for differences among learners. Therefore, within the SCIL total program package, provisions are made for: 1) diagnosis in terms of level of cognitive development, 2) lessons consistent with scientific constructs keyed to various levels of cognition, 3) freedom of choice, 4) differences in learning styles or modes, and 5) differences in experimental background and rates of learning.

REASONING ASSESSMENT TASKS

Reasoning Assessment Tasks will be developed in order to diagnose each child's level of cognitive development and to place each child in the program consistent with the developmental level. The basis for the Reasoning Assessment Tasks is Piaget's theory of cognitive development usint the pre-operational, concrete and formal operational levels since these are the stages where children in this program would most likely place.

THE MANAGEMENT SYSTEM

For each construct or segment of the program, the child follows an instructional cycle of exploration, invention, and discovery. The exploration, invention, discovery learning cycle is rooted in current theories on how children learn, notably in the developmental theory of Jean Piaget.

As an orientation to SCIL, the child learns how to function independently in the program through the Self-Management Unit. Within the Self-Management Unit, the child learns which decisions he may make, which decisions the teacher makes, and which decisions they make together. He then has the opportunity to experience those tasks for which he will be responsible and learns the management system as well as how to progress through the program.

The management system also includes materials storage, retrieval and handling. Since the teacher's role is dependent upon continual interactions with children, it is necessary within an individualized system to direct the teacher's efforts toward the child and to remove as many materials proble- as possible.

The instructional cycle can be described briefly as follows. Exploration lessons are open-ended lessons which allow the child to become involved with concrete scientific objects in any way he wishes and is the first step in the instructional sequence. The children look through a "catalogue" of exploration lessons and choose any lessons from this catalogue that they wish to do.

At the next phase, the teacher assigns the child to invention lessons based on what were found to be his interests in exploration. Invention lessons are convergent activities which invent or define through concrete activities the scientific terminology and/or the theoretical constructs in the program. Invention lessons are of several types: independent, pictorial, taped lessons and teacher-directed group activities. In the invention activities, the child may be given specific directions as to how to use the materials.

The group lessons with four to eight children are an important part of the program. These are directed by the teacher. The children have the opportunity to verbalize and interact with other children as well as with the teacher. The group lessons provide the teacher with valuable feedback as to the child's ability to use a particular construct and to verbalize and interact with other children. With this knowledge, the teacher is able to decide whether a child needs additional invention activities or that the child may go on to discovery lessons.

Discovery lessons are the final stage of the instructional sequence. They are problem-centered divergent activities where knowledge of a theoretical construct is applied to situations different from those in which the construct was invented. Discovery lessons serve as an evaluative device in the program, i.e., the criterion for the mastery of a construct is the ability to solve a variety of problems using that construct in new situations. A child who is successful in solving these problems may go on to explore other constructs in other units. Children who cannot successfully solve the problems return to invention lessons. In the discovery phase, the child, once again, has the option of doing as many lessons as he wishes, and he decides on those lessons he wants to do. When the child has completed the three phases of the cycle; exploration, invention, discovery, he goes on to another unit, repeating the instruction cycle with each new unit he encounters.

A chart of lessons for each unit, the "flow chart", is part of the management system and provides both teacher and child with a running inventory of lessons completed. This is an essential part of the management system.

It should be noted that as the child completes each phase of the instructional cycle, the lessons are checked by the teacher and the Flow Chart initialed. These are built-in check points which provide for student-teacher interaction throughout the course of a unit. Together, the teacher and child have the opportunity to review the child's work.

The cognitive and affective advantages to the child of the evolving individualized system described previously is under careful investigation. One such study is described in the next section of this paper.

The purpose of this study was to assess the results of the materials and systems tryout testing of two units of the Science Curriculum for Individualized Learning (SCIL) program. This tryout is part of the formative evalua-

tion (Scriven, 1967) phase of product development. The SCIL units were adapted from the Science Curriculum Improvement Study (SCIS) series (Karplus, 1970) by the Science Coordinator, Dr. Marilyn Appel and the SCIL staff at Research for Better Schools, Inc.

The nature of this evaluation study is descriptive and therefore uses descriptive or non-parametric statistical techniques. These techniques, the assumptions for which have been met, provide the developer with the kinds of information necessary for revisions in the lessons or in the individualized management system used in the program. Procedures employing random techniques of assignment would be more consistent with an experimental study and were, therefore, not used here. The assumptions relevant to many inferential statistics would be violated in this type of study and therefore these techniques were employed only in one instance where the evaluator felt its use would yield meaningful information.

The results of this study are limited to the present population and no inferences or generalizations are intended.

Questions Investigated in the Study

I. Questions pertaining to outcomes

a. Cognitive

1. Did the pupils achieve according to the SCIL program's operational definition of achievement?

b. Affective

1. What feelings do third grade students report toward SCIL as compared with fourth, fifth and sixth grade students?

2. In a comparison between students in a group-oriented and individualized science programs, which students report more positive attitudes towards science?

3. In a comparison between two science programs having the same content and a program having different content, which students report more positive attitudes towards science?

4. What affective responses to the SCIL program were reported by parents of SCIL students?

Definitions

For purposes of this study, the following definitions were employed:

Materials Tryout Test - a small test situation, usually involves a small number of students in a single school in one or several classrooms. The program developer and evaluators frequently observe in the classrooms with the intent of refining the program.

Systems Tryout - a classroom level test situation usually involving several units of a curriculum. The evaluation staff frequently observes and monitors the systems and management components with the intent of providing the developer with information necessary for refining the program.

Achievement - defined as a student successfully applying a construct to 5-10 discovery (problem-centered) lessons (as specified by the lesson) confirmed by the teacher's judgment. In those instances after 5 successful lessons where a child was judged by the teacher not to have assimilated the construct, it is suggested that the child complete additional discovery lessons. Progress through the program may also be considered as part of the achievement concept for in order to go from one construct to another, a student must successfully complete the discovery phase of the instructional cycle.

Attitude - "An attitude is the degree of positive or negative affect associated with some psychological object." (Thurstone, 1946) Operationally, attitude refers to responses on the How I Feel About School and Science Questionnaire (HIF-SS) and the SCIL Parent Questionnaire.

Conventional Program - characterized by group instruction, teacher selected content, usually textbook oriented, lecture, demonstration.

HIF-SS (How I Feel About School and Science Questionnaire) - an instrument used to gather affective responses and assess student attitudes towards several facets of school and science.

Formative evaluation - "The continuing evaluation of all elements of a developing educational program as an aid to the development process." (Lindvall, and Cox, 1970).

Delimitations

The following limitations should be considered when interpreting the results of the present study:

1. This study is limited to the evaluation of two units composes of four constructs - Interaction, System, Subsystem, and Variable.
2. There were two teacher strikes during the school year covering a combined total of approximately three school months.
3. There was an unexpected change in SCIL teachers three months into the school year (Dec. 18, 1972).
4. Observations were made by only one observer during the months of January-May, 1973.
5. Observations were unable to be made on the construct "variable."
6. In the tryout a formalized SCIL teacher training package had not as yet been developed. Thus, teacher training was ad hoc on-the-job training, as communicated by the developer.

Population and Environment

The SCIL program was tested at an inner city elementary school in Philadelphia, Pennsylvania. The school has a student population which is both racially and economically mixed.

Table 1 describes the distribution of the student population by grade level.

All SCIL classes except for 6th graders met twice a week. Sixth grade classes met once a week. All SCIL classes met in one designated science classroom.

The SCIL school population in September, 1972 was 345. For purposes of answering individual evaluation questions posed by this study samples of this population were randomly drawn. The use of smaller samples was necessitated by the limitations of available time and manpower. The sample associated with each evaluation question is presented along with that section of the study. Since new students entered, the program after the school year began the total number of students at the end of the year was larger than at the beginning.

TABLE I

DISTRIBUTION OF THE STUDENT POPULATION AT THE SCIL SCHOOL

ACCORDING TO GRADE LEVEL

In September, 1972.

Grade Level	Number of classes	Total N	% Total
3	2	66	19
4	2	63	19
5	4	105	30
6	4	111	32
Totals	12	345	100

Teacher and Teacher-Aide

One teacher taught all SCIL classes. The teacher responsible for the SCIL program for the greater part of the school year had six months prior teaching experience on the junior high school level and had no prior knowledge of either the SCIS or SCIL programs.

One teacher aide was assigned to the SCIL classroom. The aide has worked with the SCIL program for two years and is thoroughly familiar with the procedures and material.

Methods of Data Collection

To determine if the students achieved the intended outcome of a lesson, an observation form was used to record 135 kinds of observations on 81 students. The 81 students constituted 25% of the SCIL student population. In this process, children were interviewed directly and observations were made while they were at work.

Student Questionnaire

The HIF-SS student questionnaire (see Appendix A) was administered to all SCIL students in the SCIL school and to students in two control schools which were determined to be comparable to the experimental school in terms of racial and socio-economic makeup.

The HIF-SS is a 40 item questionnaire composed of five scales. Table II describes the reliability of the HIF-SS by scale.

TABLE II

RELIABILITY* OF THE HIF-SS

BY SCALE

Scale**	Measures	Internal Consistency Measure
1	Attitude toward science class	.71
2	Self-direction in science	.70
3	Attitude toward science in general	.76
4	Attitude toward science lessons	.60
5	Attitude toward what goes on in science class	.81

* Coefficient Alpha
** N = 628

Parent Questionnaire

The parent questionnaire (see Appendix B) was mailed to the parents of all 330 SCIL students during the third week of May, 1973. The parent questionnaire contained eight items and a comment section.

SECTION 2

QUESTIONS RELATED TO COGNITIVE AND AFFECTIVE OUTCOMES

1. The first question to be investigated is: Did the students achieve according to the SCIL program's operational definition of achievement? Two forms, a student observation form and the student flow chart, were used to gather data concerning this question. Direct observations were gathered on 37 students as they worked on particular lessons between January and May of 1973 via the student observation form and are reported in Table III. Data were gathered between January and May of 1973 on two constructs Interaction and System.

TABLE III

NUMBER OF SCIL STUDENTS BY GRADE AND CLASS WORKING ON EACH CONSTRUCT WHEN THE SCHOOL YEAR ENDED

Construct	Grade	3		4		5				6				TOTAL N
	Class	1	2	1	2	1	2	3	4	1	2	3	4	
Interaction	E		1											1
	I	1	1											2
	D	4	4	1			1			4	1		3	18
System	E	2	6	5			1	1		2	2	1	2	22
	I	4	7	5	7	1	1	0	3	6	9	6	8	57
	D	7	4	5	5	5	6	3	1	5	8	10	9	68
Subsystem	E	8	8	9	3	2	2	3	5	4	4	5	4	57
	I	9		2	0	4	1	4	1	3	2	4	0	30
	D	1		2	8	5	3	8	4	2	0	0	3	36
Variable	E	1		1	5	2	2	3	1			1	1	17
	I	2			2	2	4	2	1	1				14
	D				4	5	6	1	7		2	1		26
Total/Class		39	31	30	34	26	27	25	23	27	28	28	30	
Total/Grade		70		64		101				113				*348

* Total population presented throughout this report will vary because students entered and left the SCIL program during the school year.

Table V presents the number of SCIL students by grade and class working within each construct when the school year ended. It should be noted that children began the program with Interaction and worked sequentially through to Variables although there was no necessity or rule for progressing through the program in this manner. It is evident from the table that the numbers vary across grades for each construct and for each class as one goes through the list from Interaction to Variables. It is also evident that individual children at each grade level progressed through the program at varying rates of speed. Because of teachers' strikes, teachers' absences and a change in teachers, the maximum number of instructional periods for 3rd, 4th and 5th grades was approximately 30 and for 6th graders the maximum was approximately 15.

No comparison involving pre and post measures were carried out. However, cognitive gains can be inferred from a child's performance on the Discovery lessons. These problem-centered activities require the child to apply concepts learned in the Invention and Exploration lessons. Therefore, if a child was judged by the teacher to have satisfactorily completed a minimum of five Discovery lessons, it may then be inferred that he achieved cognitive gains from the particular unit. By inspecting the records of all the SCIL children, the number completing Discovery lessons for each unit was determined. Four sets of Discovery lessons completed was the upper limit. Note that 92% of the children completed one or more sets of Discovery lessons. Table IV presents these results.

TABLE IV

THE NUMBER OF STUDENTS COMPLETING SETS OF DISCOVERY LESSONS

# of Children*	Grade	# of children completing Discovery Lessons for each of four constructs			
		1	2	3	4
61	3	56	27		
60	4	54	25		
100	5	95	78	14	1
109	6	98	27		
330	TOTAL	303	157	14	1

*Several children left the program before completing Discovery lessons.

2. The second area investigated in this section pertains to affective outcomes. The following questions were investigated.

1) Since the units Interaction and Systems, Subsystems and Variables were geared more to children at the lower grade levels than those at upper grade levels, a comparison was made between 3rd graders responses and the sum of 4th, 5th and 6th graders responses. What feelings do third grade students report toward SCIL as compared with fourth, fifth and sixth grade students?

2) In a comparison between students in a group-oriented and individualized science programs, which students report more positive attitudes towards science?

3) In a comparison between two science programs having the same content and a program having different content, which students report more positive attitudes towards science?

4) What affective responses to the SCIL program were reported by parents by parents of SCIL students?

Table V presents the number of children in each grade and each school who were administered the HIF-SS.

TABLE V

DISTRIBUTION OF STUDENTS ADMINISTERED THE HIF-SS IN MAY 1973

School	Grade Level				Total N
	3rd	4th	5th	6th	
SCIL	54	62	88	97	301
SCIS	22	54	53	33	162
Conventional*	69	28	33	35	165
Total	145	144	174	165	628

* Conventional - see definition

The instrument used to obtain the student affective responses was the HIF-SS. This is described in previous discussion of instrumentation.

Findings:

1. In a comparison between 3rd grade SCIL students and 4th, 5th and 6th grade SCIL students on the HIF-SS it was found that the 3rd grade students chose significantly more positive responses. The five scales which comprise the HIF-SS were used. Table VI presents these findings.

The Z test statistic was used in this comparison because the assumption of random assignment was not meaningful. Random assignment to grade is never carried out in a real world setting. Holding this assumption in obeyance and meeting the other assumptions for analysis of variance the Z technique was executed.

The Z technique is identical to the t test except that the degrees of freedom are infinite. It should again be stressed that this was an evaluative study designed to inform and aid the developers. Inferences to population were not of interest at that time.

TABLE VI

COMPARISON OF MEAN SCORES OF 3RD GRADE SCIL STUDENTS WITH 4TH-6TH GRADE SCIL STUDENTS ON HIF-SS SCALES

Scale	Measures	3rd grade	4-6 grade	Independent Z Value
1	Attitude toward science class	10.43 †	12.90	5.78 *
2	Self-direction in science	21.59	24.31	3.68 *
3	Attitude toward science in general	17.41	21.17	5.48 *
4	Attitude toward science lessons	10.09	11.57	3.33 *
5	Attitude toward what goes on in science class	20.52	24.47	5.01 *

† Lower scores indicate more positive affective responses chosen

* $P < .20$[1]

1. Significance Levels:

All significance levels for this study were set at .20. This is indicated by using the symbols $P < .20$ and indicates that significant differences might be found only twenty times in one hundred by chance alone when no true difference existed. The use of this level is postulated on the concept that formative evaluation is not a final decision process. Therefore, the reader is invited to decide on the relative merit of the differences for his own purposes.

2. Third grade students in the science program which is individualized (SCIL) appear to have a more positive affective response on three scales of the HIF-SS than do third grade students in the group-oriented science program (SCIS). No differences in attitudes between the groups were found on the other two scales. Table VIII presents these findings.

TABLE VII

COMPARISONS OF STUDENT RESPONSES TO THE FIVE SCALES OF THE HIF-SS: INDIVIDUALIZED VERSUS GROUP-ORIENTED SCIENCE PROGRAMS

Scale	Measures	More Positive Responses	Chi Square	df
1	Attitude toward science class	Individualized	36.68 *	15
2	Self-direction in science	No Difference	16.61	20
3	Attitude toward science in general	No Difference	20.13	18
4	Attitude toward science lessons	Individualized	38.73 *	11
5	Attitude toward what goes on in science class	Individualized	32.20 *	22

* P < .20

3. Third grade SCIL and SCIS students who have programs using the same science content appear to have a more positive affective response on two of the five HIF-SS scales than do third grade students in the conventional science program where the science content is different. On three other scales no differences were found. Table IX presents these findings.

TABLE VIII

COMPARISONS OF THIRD GRADE STUDENT RESPONSES TO THE FIVE SCALES OF THE HIF-SS: SCIL - SCIS SCIENCE CONTENT VERSUS CONVENTIONAL SCIENCE CONTENT

Scale	Measures	More Positive Response	Chi Square	df
1	Attitude toward science class	SCIL-SCIS	29.20 *	15
2	Self-direction in science	No Difference	14.22	20
3	Attitude toward science in general	No Difference	19.68	18
4	Attitude toward science lessons	SCIL-SCIS	19.63 *	11
5	Attitude toward what goes on in science class	No Difference	26.79	32

* $p < .20$

There was one item on the HIF-SS which was administered only to the SCIL students. "I am afraid to make a mistake on my lesson sheet." It was the developer's intent that SCIL students should not fear making mistakes on lesson sheets. Data indicates that 76% of students chose responses congruent with this intent.

4. Of the 330 SCIL parent questionnaires mailed, 177 or an unexpectedly high 54% were completed and returned. In addition, 35% of the parents responding offered comments about the program, teacher, and the new report card system. Table IX presents the responses of the parents to the first seven questions.

TABLE IX

RESPONSES TO QUESTIONS ON SCIL PARENT QUESTIONNAIRE

QUESTION	N	% YES	% NO
Does your child seem more interested in science now as compared to before he was in the SCIL program?	177	88.1	11.9
Does your child sometimes use new words at home that he did not use before such as subsystem, interaction, system, exploration, BTE, evidence or inversion?	177	74	26
Does your child sometimes try to do science lessons at home since entering the SCIL program?	177	57.6	42.4
Does your child talk about science class more now at home since entering the SCIL program?	177	73.4	26.6
Has your child mentioned that he is learning science in a new and different way?	177	82.5	17.5
Has your child told you he is happy about the new and different way he is learning science at school?	177	78.0	22.0
Are you pleased with the new way in which your child's progress in science is reported?	176	82.5 *	16

* Not equal to 100% because of one NO RESPONSE.

The SCIL students' parents were also asked to report their perception of their child's favorite subject. Table XII presents the results.

TABLE XII

PERCENTAGE† OF SCIL STUDENTS BY GRADE FAVORING DIFFERENT SUBJECTS AS PERCEIVED BY THEIR PARENTS

GRADE	Subject						
	No Response*	MATH	Lang. Arts	SCIL Science	Social Studies	None	Other
3	3.1	16.2	18.9	35.1	0.0	10.8	10.8
4	15.?	21.2	15.2	30.3	0.0	3.0	15.2
5	7.5	17.0	22.6	17.0	15.1	9.4	11.3
6	3.7	31.5	31.5	11.1	1.9	9.3	11.1
All	7.9	22.0	23.2	21.5	5.1	8.5	11.9

* N = 177 † Does not equal 100% due to rounding.

It was found that 3rd grade students had a more positive affective response toward SCIL on all the attitude scales than did the 4th, 5th and 6th grade students.

In a comparison between students in group-oriented programs and those in an individualized program (SCIL) it was found that the students in the individualized program had more positive affective responses on three of five attitude scales: these are: attitude toward science class, science lessons and to what goes on in science class. There were no differences found on the other two scales which deal with self-direction, attitude toward science in general and what goes on in science class.

Parents of SCIL students completed questionnaires which asked for their perceptions of their children both before and after entering the SCIL program. These parents indicated that their children are perceived as liking science more since entering the SCIL program. The percentage of positive responses to the seven questions answered by the parents ranged from 57.6% to 88.1%. Eighty-two percent of the parents also chose positive responses to a new reporting system for science.

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