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As a result of the Biological Sciences Curriculum Study (BSCS), instructional content and style were studied in six teachers teaching the concept of photosynthesis. The same BSCS curriculum program was used by all six teachers, all six had some previous BSCS training. The students in the six classes had been selected on the basis of high ability and/or high achievement. Three consecutive class sessions were recorded during the introduction of photosynthesis and analyzed by the topic classification system of Aschner, Gallagher, and others. Significant interteacher variations were found on dimensions on teacher intent and level of conceptualization but not on teacher style. Wide variations were found among emphases on various biological concepts or background materials. It was thus concluded that using the same curriculum materials does not insure similar instruction. (Author/JD)

TEACHER VARIATION IN CONCEPT PRESENTATION

IN BSCS CURRICULUM PROGRAM

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Evanston Township High School	Evanston, Ill.
Oak Park & River Forest High School	Oak Park, Ill.
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Willowbrook High School	Villa Park, Ill.

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BACKGROUND

The classroom, with its complex social structure and kaleidoscope of cognitive and psycho-sociological variables, has not often been the object of serious research. Content area specialists have concentrated on the sequential organization of materials and have left the direct applications of these materials, either to the intuitive strategies of the teacher or, at best, to the imitation of a master teacher.

Consequently, the essence of teaching has remained a mystery and we often hear the statement that 'teaching is an art'. It certainly is, with all that statement implies. There are very few true artists (as with other artistic endeavors) and even the great artists cannot tell others how their own success came about. We heap praises upon our great teachers and professors at the end of their careers but a large part of their greatness as a teacher dies with them, and will continue to do so until the character of their effectiveness can be more objectively described.

> Is a great teacher one who knows his content field well? We may draw a merciful veil over the innumerable teachers who 'know the subject but not how to teach it'.
>
> Is good teaching merely a sensitivity for the individual student? Certainly not alone, and sometimes not at all.

> Would you rather have a teacher who knows content but not methods, or one who knows methods but is weak on content? School administrators are often faced with just such an unhappy choice.

Obviously we have a blend of variables, and different blends may wear equally well under a variety of circumstances, but we must first know what the blends are. This investigation is designed to help define further the teaching process as shown in a series of BSCS biology classes for superior students.

The investigation of teaching effectiveness through analysis of the teacher's personality has not borne much fruit. Getzels and Jackson (1963) in summarizing the literature commented:

> Despite the critical importance of the prodigious research effort, very little is known for certain about the nature and measurement of teacher personality or about the relation between teacher personality and teaching effectiveness. (p. 574)

An alternative approach has been to study the teaching process itself through direct observation and analysis. It has only been in the last decade that systematic attempts to investigate the complex and sequential interactions of ideas presented in the classroom have gained real prominence. The combination of improved methods for obtaining permanent recordings of classroom behavior and improved psychological and educational theory has provided the impetus for such investigators as Flanders (1963); Smith and Meux (1962); Spaulding (1963); Taba, Levine,

and Elzey (1964); Aschner, Gallagher, et al. (1965); and others to initiate methods of studying this complex social environment.

While many of the above systems have concentrated on the affective or emotional dimension, they have established, in their initial applications, some useful bits of information that seem relevant to the more cognitively based present system. These are:

> Teachers differ in their style of classroom behavior.
>
> Teachers from different training backgrounds show different classroom styles.
>
> The type of patterns used by the teacher influences the type and amount of student learning.
>
> These teaching styles are capable of modification through training.

The Reform Movement of BSCS

The Biological Sciences Curriculum Study, organized in 1959 by the education committee of the American Institute of Biological Sciences, represents one of a number of reform movements in curriculum development for the schools. By the middle 1950's many physical scientists and mathematicians had become increasingly disturbed regarding the content of the material presented in their speciality at the secondary school level. This problem had been made more serious by the rapid development of new knowledge in the sciences. Whatever the field of speciality, a review of existing textbooks showed that their attempts to squeeze new information into traditional texts had only created a weird patchwork quilt from which the most brilliant student or the most capable teacher was hard put

to extract important generalizations. (See Bruner, 1960).

Groups of scholars in the various disciplines took it upon themselves, often in cooperation with educational personnel, to design and construct new sets of curriculum materials that would reflect more adequately the status and intent of the sciences. These ventures, supported in large part by financing from the National Science Foundation, have played a highly significant role in secondary education over the past decade. (See Goodlad, 1964).

Schwab (1963) has reported upon three phases in the development of the biological materials for the schools. The first phase he identified extended from 1890 to 1929 during which time the biology curriculum and its texts were descriptive and consisted of a mass of disconnected facts and primitive generalizations. The second phase Schwab identified as lasting from 1929 to 1957. During this time an emphasis was placed on the social sciences and on the importance of individual differences and student characteristics for learning efficacy. One of the consequences of this orientation, and consequent deemphasis of the content area specialist, was that less than 10 percent of the high school science textbooks were produced during this period by authors on the roster of American Men of Science (Brownson and Schwab, 1963). In other words, the textbooks were being written by educators rather than by specialists in the individual discipline. The BSCS operation, therefore, was designed to reinstitute the role of the scholar in curriculum development in his discipline.

This group, like others of similar nature such as the Physical Science Study Committee, the School Mathematics Study Group, the Chemical Bond Approach, etc. had as its goal the

following:

1. The presentation of a structure of important interlocking ideas and concepts that lie at the heart of their discipline. They were willing to sacrifice breadth of coverage of an area so that the students could grasp this essential structure.

2. They were committed to the idea that one of the best ways for a student to understand science was to act like a scientist. Therefore, he should play an active role in conducting of experiments and in performing in the scientist's role as much as was feasible.

While the BSCS has attempted some large-scale evaluation (Grobman and Wallace, 1962), the very nature of comparing hundreds of classes and thousands of students tends to obscure factors internal to the classroom that are potentially related to achievement.

In many respects, the major curriculum movements have operated on an assumption, often unstated, that the key variable of student outcome was rather exclusively a function of curriculum organization. This exuded a degree of confidence in curriculum organization that would not be held by those who have studied student outcome variables under other circumstances. Instead, student outcome or achievement is likely a function of curriculum organization, student ability, teacher content knowledge, teacher strategy in presentation of ideas, the student's past knowledge of the subject, motivation, etc.

PROCEDURES

Previous attempts to observe instructional content and style have often been defeated by the large number of variables that might influence student performance. Differences in teacher or student behavior might be the result of the particular set of concepts being taught, the ability level of the students, the past experience of the students, or the background of training and preparation of the teacher, etc. It was the purpose of this study to attempt to control some of these variables so that the personal style of teaching would be the major variable left to influence the performance.

Subjects

The subjects in this study were six biology teachers and their classes of high ability students who were studying the BSCS Blue Version Molecules to Man. All of the teachers were instructing the classes in suburban communities outside of a metropolitan area and all had had some previous training contact with the BSCS program. All teachers who were contacted agreed to participate in the study.

The students were selected for these classes in the six suburban classes on the basis of high ability and/or high achievement. The aptitude scores for five of the six class groups may be seen in Table 1. Since the results were obtained on a number of different tests, these have been transformed into standard scores to make a comparison easier. The sixth school maintained a policy of not releasing aptitude scores and thus these were unavailable. There is no reason to believe, however, that this class would vary substantially from the same general character of the groups for which data was obtained. As can be seen from Table 1, all of the groups showed the general characteristics expected of honors classes.

The selection of the particular concept of photosynthesis

Table 1

SAMPLE CHARACTERISTICS ON APTITUDE AND CA

CLASS	BOYS					GIRLS				
		Aptitude z Score		CA (in months)			Aptitude z Score		CA (in months)	
	N	Mean	σ	Mean	σ	N	Mean	σ	Mean	σ
URIAH	19	(none available)		171.53	5.41	5	(none available)		169.80	2.69
VIRGIL	9	120.36	5.24	172.33	5.00	13	116.12	7.01	171.77	4.18
WILLIE	10	122.00	6.82	174.56	3.68	10	119.37	5.02	170.56	5.00
XAVIER	12	116.06	2.71	173.17	4.04	7	116.09	1.97	173.67	3.43
YANCY	13	122.75	4.71	173.31	3.57	4	123.52	4.67	172.25	1.26
ZORBA	14	126.53	5.39	182.21	4.31	12	125.97	5.16	184.75	4.79

to be used as the focus of the recordings was made in consultation with the BSCS staff at Boulder Colorado who felt that this concept would give maximum latitude for the development of important ideas and generalizations. The Blue Version of BSCS was chosen in preference to the Green or Yellow versions on the basis of geographical convenience of the investigator. The criterion was how easy it would be to reach teachers using this set of materials.

Recordings

Arrangements were made to record each of the classes in their discussion sections for three consecutive days while the teacher was introducing the subject of photosynthesis. In each instance, the instructor informed the investigators as to what date they would begin the discussion of this concept. The arrangements were then made to record on that date. It is interesting to note, in passing, that there was a range of about a month-and-one-half as to when each of the instructors reached this point in their year's sequence.

The technical arrangements were the same in each of the recorded sessions. Three directional microphones were used and the resultant sound was placed into a mixer thence into an Ampro tape recorder. At least one of the staff members of the project and sometimes two were present during the recording and helped arrange and balance the sound. One day of practice was used in order to establish appropriate sound levels and also to acclimate the students to the presence of the equipment before actual recordings were taken.

The observer in the classroom had a seating chart available to him identifying the students and attempted to take continuous notes, identifying the speaker wherever possible.

The translation of the recording into a final tapescript for analysis followed this procedure. The observer who was present in the classroom would listen to the tape recording and then dictate into a dictaphone what he heard on the tape and recalled from his notes. This was found to be most preferable to a seretary attempting to take the information directly off of the tape since the specialized vocabulary and the general difficulties of comprehending softly spoken voices made direct secretarial transcription too difficult. This dictated rough draft was then edited and corrected by the observer and one other member of the staff and a final tapescript was thus produced.

The Topic Classification System

The present classification system developed out of a seven-year period of research and supplements an earlier system (Aschner, Gallagher, et al.,1965). The purpose of this system is to indicate the level of conceptualization, the style of thinking and the emphasis of the instructor on skills or content in classroom discussion. Figure 1 gives a schematic picture of the three dimensions in this system which allows the investigator to analyze sub-units called topics in terms of instructionally relevant variables.

Each investigator in the field of classroom interaction has felt the need to establish some units for the purposes of analysis. Sometimes these have been simply the individual statements of discussion participants and sometimes they have involved larger segments of classroom activities.

In this system the term topic is used to delineate a unit where the focus of classroom discussion centers on a given action, concept or principle. Classroom discussions do not necessarily follow orderly sequences. Therefore, the length of

time spent on a subject under discussion determines its status as a topic rather than the place it might or might not hold in an orderly or logical sequence. A more thorough description of the topic, it divisions and classifications, are given in Gallagher, Shaffer, et al. (1966).

In a given one-hour class session, one normally expects to find between 15 and 25 Topics. These, in turn, can be grouped under larger headings entitled Themes. A Theme is a unifying element for a group of related topics which represents a larger idea encompassing a series of topics. One would generally expect to find one to four themes for one hour's script.

Content-Skills. This dichotomous dimension refers to distinctly different teaching goals. Content refers to the goal of injecting a given body of knowledge into the student. Information, ideas, or concepts are presented to the student and he is expected to absorb them.

The second area, Skills, refers to the goal of teaching the student a set of behaviors or skills which will enable him to master successfully situations that he will meet in the future. Such activities as instruction in reading skills, learning grammatical rules, mastering mathematical operations, are referred to as Skills. So are the broader concepts of learning the scientific method, learning how to design and execute an experiment, how to handle data , all of which have specific relevance to the BSCS curriculum.

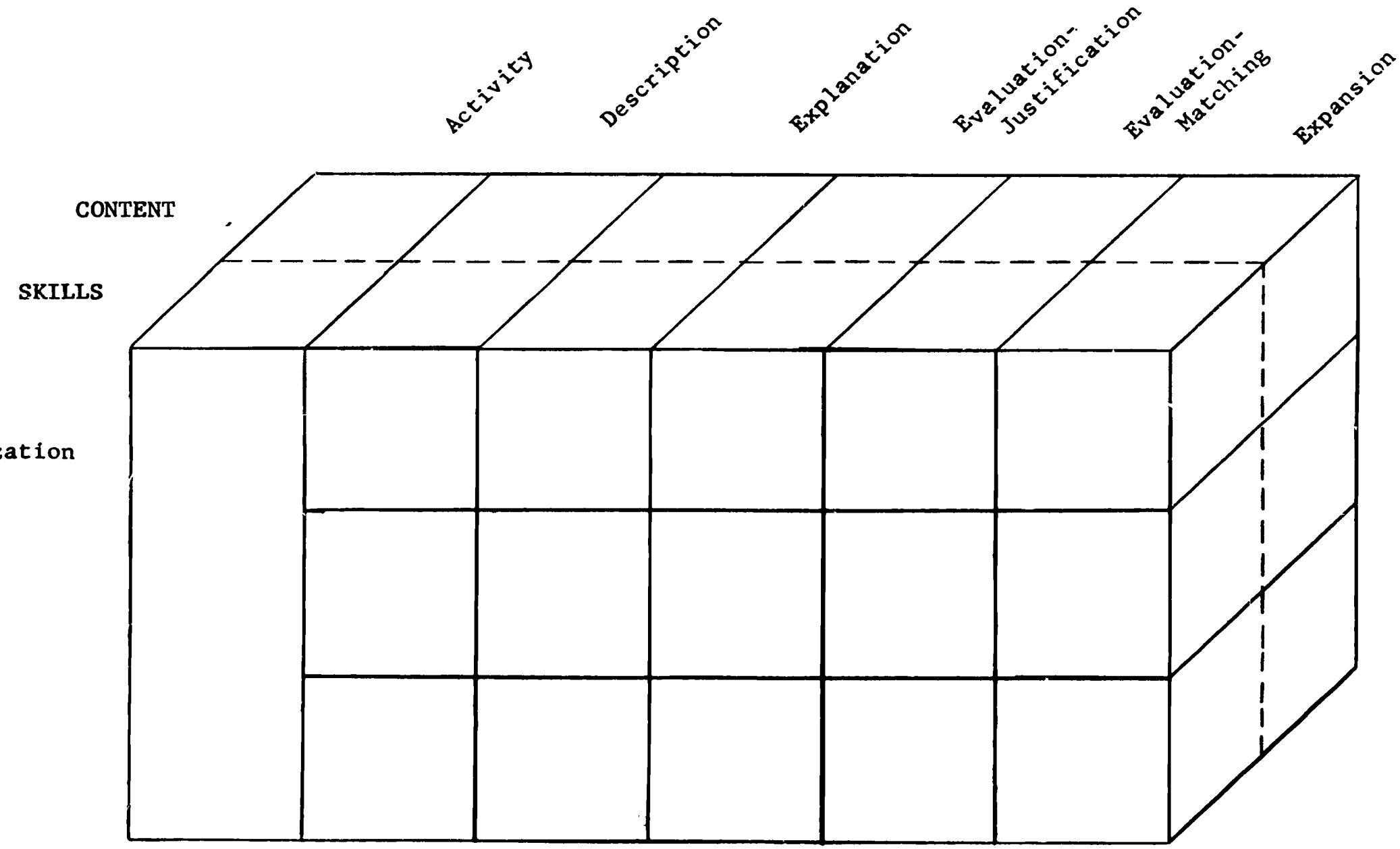
Level of Conceptualization. One weakness of previously constructed classification systems has been their lack of consideration for the level of conceptualization. In a curriculum where the importance of an idea is judged crucial, a classification

system should indicate whether or not the class is generally operating on a high or low abstract level. The three levels utilized in the present system are crude and a deliberately limited view of a more infinitely complex abstractional ladder. Data represents the discussion of specifics, the individual event or instance, the personal anecdote, the concrete level of happenings. Concept represents a certain degree of abstraction of data to general ideas and their applications or associations. Generalization represents the larger ideas or concepts in relationship to one another as found in a scientific law or the general principles of economics or history.

Style. This dimension deals with the style of thinking evident in the discussion held in the classroom. It focuses on how information is being processed, the focus of a topic in a class session can be on Description, or the defining or describing of aspects of a concept or event; on Expansion, which would lead the group off to other lines of thinking or encourage new associations; on Explanation, which would focus on reasoned argument through sequential deductive steps of thinking; or Evaluation-Justification, which reveals an attempt to make a decision and then explain the reasons for the judgment; or Evaluation-Matching, which depends upon the presence of previously established criteria for judgment and attempts to match events or circumstances to those criteria.

In applying the classification system to the scripts in the present study a procedure was followed that had been found workable in a previous research project (Gallagher, 1965). Two judges would independently rate each script, first making topic divisions and then classifying. These judges then would condense their decisions on classification. If any decisions

Figure 1. Topic Classification Dimensions--Classroom Interaction Analysis



remained unresolved as a result of this consensus meeting they were brought before the total staff for discussion and sometimes used for modification or extension of established rules.

It was found necessary to consistently use two judges since it was difficult to keep a firm frame of reference on the entire system and consensus helped iron out tendencies to overlook a category or overemphasize a category during a classification session. Reliability in this case is not determined by a comparison of the two individual judges but rather between two teams of judges operating in this fashion.

Figure 1 portrays the three dimensional classification system. A topic was classified in each of the three dimensions. Thus, a topic whose focus would be on the definition of an autotroph would be CONTENT-CONCEPT-DESCRIPTION. A topic whose focus would be on how to record data stemming from a class laboratory experiment would be SKILLS-DATA-EXPLANATION, and so forth.

Table 2 gives some examples of topics that would fall into various cells of the present classification system. By following the columns up in Table 2 the reader can grasp the change in abstraction level. By following the rows across one can see the change in style and emphasis. The Content vs. Skills dimension is not included in this table. One example of this distinction would be:

Skills - The description of a microscope and how it is to be used in collecting observations.

Content - The discussion of the history of the microscope and its invention.

Table 2

TOPIC CLASSIFICATION OF BIOLOGICAL CONCEPTS

	DESCRIPTION (D)	EXPANSION (E)	EXPLANATION (X)	EVALUATION (V)
GENERALIZATION	The system of photosynthesis.	What would happen if the system of photosysthesis ceased functioning?	Show how the system of photosynthesis explains the change in leaves from brown to green.	Does this represent an adequate statement for photosynthesis? $CO_2 + H_2O \rightarrow [CH_2O] + O_2$
CONCEPT	The definition of a heterotroph.	Contrast the autotroph and the heterotroph.	How do we know that the oxygen from photosynthesis comes from water?	Do you believe it was essential that autotrophs developed?
DATA	What colors do you see in the spectroscope. Record them.	Comparing the black vs. white cloths their ability to absorb light.	Describe in sequence the experiment by Calvin.	Was our experiment a success?

RESULTS

The Results of this study are presented first in terms of teacher behavior then, in terms of student performance. When possible, statistical tests were applied to determine the significance of the variation between teachers and between classes of students.

Topic Classification System.

Table 3 presents a summary of the percentage of topics occurring in each dimension of the Topic Classification System for each classroom. The total number of topics for the three days of recordings ranged from 45 to 61, or about an average of from 15 to 20 topics per class session. Since there were variations in the length of class period, the key data here are presented in the form of percentages.

In the first dimension of the system, Goals, there was a substantial difference between teachers in terms of their overall strategy. The percentage of Skill topics ranged from zero in YANCY and ZORBA to about 30% of the total in VIRGIL and WILLIE. The majority of the Skills topics found in the present study were focused at the Data and Concept level of abstraction. They ranged from the specific of 'How to work with this tube of chlorophyll' to 'How to obtain a pH value with indicator dyes' to the more general topics focusing on 'The value of using chromotography in collecting data' and 'The use of constants in scientific formulas.' The purpose of these Skills topics seemed to be on the development of greater student aptitude to act in the role of a scientist and appeared to be directly related to one of the major goals of the BSCS program, teaching science as inquiry. Despite this common goal, there was

Table 3

PERCENT OF TOPICS IN EACH DIMENSION OF CLASSIFICATION SYSTEM

		GOALS		LEVEL			STYLE				
Class	Total Topics	Content	Skills	Data	Concept	General.	Descr.	Explan.	Eval-J.	Eval-M.	Expans.
URIAH	55	96	4	7	91	2	31	40	7	0	22
VIRGIL	45	71	29	27	68	6	33	48	9	0	9
WILLIE	61	70	30	32	64	4	48	38	4	0	11
XAVIER	48	85	15	26	58	16	44	37	2	0	17
YANCY	60	100	0	3	95	2	39	46	7	0	8
ZORBA	57	100	0	11	80	9	38	47	2	2	11

$X^2 = 48.84$ $X^2 = 34.77$ $X^2 = 14.98$

df = 5 df = 10 df = 30

p = $<.01$ p = $<.01$ p = .99

significant variation between the six classes in terms of the frequency with which these matters were focused on in class discussion.

This does not mean that those teachers not showing any Skills topics in this analysis did not pay attention to this goal. It is quite feasible that in laboratory sessions or in discussions with individual students these topics did receive attention.

In terms of the Level of Conceptualization, Table 3 again shows substantial differences in the percentage of topics used in the current class sessions. At the highest level, Generalization, which demanded a focus on a large idea with broad application or a discussion of an abstract system, the range of percentage of total topics was from 2 to 16%. In those classes receiving the higher percentages there were discussions on the interrelated parts of the photosynthesis process, discussions of glucose conversion to starch and several generalizations on the nature of light.

An interesting pattern was revealed in YANCY where 95% of all topics were found to be at the Concept level with little Data or Generalization being focused upon. There is some reason to believe that the Generalization level is hard to attain without a substantial amount of concrete data present in the students' perception or memory bank. VIRGIL and WILLIE both show an affinity for discussions focusing on specifics (27 and 32 % Data topics) which corresponds to the presence of Skills topics in their classes.

A Chi Square test on the proportions involved under Level of Abstraction indicated a highly significant difference between teachers on this dimension.

In the third general dimension of the classification system, Style, there was a fairly common pattern revealed across all six teachers, with a great emphasis on topics in the areas of Description and Explanation. From 71 to 85 % of the topics fall in those classifications in the present sample. There were few topics which dealt with Evaluation or decision making of any sort. The greatest variation

in Style categories was found in the Expansion dimension, with URIAH showing 22% of the topics in this dimension, while YANCY revealed a low of 8%.

One can note also that the Evaluation-Matching category was hardly used at all. This means that judgments made on the basis of a matching of instances or data to an established criterion or criteria was one type of topic that rarely was seen in these classes. The high percentage of Expansion topics in URIAH was due to some degree to his extensive use of graphs in class discussion. The translation of data from one medium to another, from figural to verbal, was one major criteria for the Expansion category. A comparison and contrasting of two or more ideas also increased the Expansion topic count in that instance. A Chi Square test of the difference between teachers failed to reveal significant difference in Style and suggested that the patterns shown by these six teachers were consistent with one another with the emphasis resting strongly on the dimensions of Description and Explanation.

Overall, there were significant differences between teachers found in two of the three major dimensions of the Topic Classification System. In Goals and Levels, there were sufficient teacher variations to suggest that the individual teacher was having a substantial impact on how the biological concepts will be presented in class discussion in these dimensions. Only in the Style dimension did the teachers seem to show some degree or uniformity of pattern.

Concepts Discussed.

Table 4 shows the number of topics included in the three days of recording that were related to the concepts in Chapter Nine of the text, Molecules to Man. This data was obtained by having readers familiar with the chapter read each topic and attempt to identify the predominate material in either the text or the invitations to learning that were involved. In addition to Chapter Nine which was the major

Table 4

NUMBER OF TOPICS COVERED IN CLASSROOM INTERACTION

LIGHT AS ENERGY FOR LIFE

Evolution in a Changing World

The changing environment

A new form of life--the autotroph

A problem of energy change

The nature of light

The raw materials and the products

Factors that affect photosynthesis

An energy-changing molecule

Photosynthesis--A Series of Reactions

Carbon in carbon dioxide becomes carbon in carbohydrate

Energy carriers in the reactions of photosynthesis

Oxygen--an important by-product

	URIAH	VIRGIL	WILLIE	XAVIER	YANCY	ZORBA
9-1	3	2	2	0	1	0
9-2	5	4	0	1	3	0
9-3	0	0	0	0	1	0
9-4	10	0	7	9	1	2
9-5	6	0	2	2	2	2
9-6	8	0	0	2	2	10
9-7	4	1	0	3	6	5
9-8	5	1	0	0	5	4
9-9	0	1	0	0	0	6
9-10	0	0	0	0	1	1

Table 4

NUMBER OF TOPICS COVERED IN CLASSROOM INTERACTION (CON'T.)

		URIAH	VIRGIL	WILLIE	XAVIER	YANCY	ZORBA
LIGHT AS ENERGY FOR LIFE							
The Evolution of Photosynthesis							
The similarity and variety of photosynthesis	9-11	0	0	0	0	2	1
Living material for experimental use	9-12	0	1	0	0	0	0
The first autotroph	9-13	0	1	0	0	0	1
The Development of Respiration							
Oxygen for evolving organisms	9-14	0	0	0	0	0	0
Respiration and fermentation compared	9-15	1	1	0	0	1	4
The mitochondria and enzymes	9-16	0	0	0	0	0	1
The citric acid cycle	9-17	0	1	0	0	1	4
EXTRA TOPICS (Text)							
Chapter 5		0	0	16	2	0	0
Chapter 6		0	2	0	0	0	3
Chapter 19		0	0	0	2	6	3
Investigations		0	4	12	8	0	2
EXTRA TOPICS (Non Text)		12	24	25	20	25	10

focus of interest, other chapters in the text, Molecules to Man, were viewed. In most cases no difficulty was found in assigning a topic to a proper slot.

Table 4 indicates the wide diversity of emphasis placed by the six instructors on the common curricular materials. The section on the nature of light provides one example of many. URIAH had a total of ten topics on this subject over three days, while WILLIE had seven and XAVIER nine. In contrast, VIRGIL had no discussion of the topic at all, YANCY had one topic, and ZORBA had two. Since these results represent only the first three days of recording on this theme it is quite likely that, as the themes were further developed, some of these areas would receive their proper attention, but the difference in emphasis in introducing the theme is striking. ZORBA paid no attention at all to the autotroph and the changing environment which is supposed to be an introduction to the topic but paid a great deal more attention to photosynthesis as a series of reactions. He also felt that the general concept of respiration was important for the students' understanding, and thus spent a good deal of time, a total of nine topics, on that area, something that few of the other instructors did. In the introductory section of the chapter, Evolution in a Changing World, the number of topics ranged from 36 in URIAH to 7 in VIRGIL. Similar variation was found between teachers on the use of figures and illustrations in the text.

In terms of topics that fell within the text but outside the particular chapter, it can be seen in Table 4 that WILLIE had a total of sixteen topics that related to material in Chapter Five, primarily the chemical underpinning for the concepts in photosynthesis. Only XAVIER of the other five teachers felt it necessary to refer to Chapter 5. WILLIE also spent more time on discussing investigations than any of the other instructors. Two of the instructors, URIAH and YANCY, had no discussion of the investigations at all. YANCY spent a total of six topics in Chapter Nineteen, the Photosynthetic Systems,

that he felt necessary to a fuller understanding of the concepts of photosynthesis. In addition there were a number of topics that did not seem to fit anywhere in the established framework and these are listed on the bottom of Table 4. One can note that URIAH and ZORBA spent the least amount of time outside the general area of discussion, while the others spent a considerable amount of time beyond the scope of the topic. Over 40% of the topics in four of the classes were judged outside the immediate discussion area. It is quite conceivable that more sophisticated biologists than those doing this analysis might have seen relationships not seen by reviewers, and it need not be concluded that the extra topics were not relevant to the discussion that developed.

What this table apparently does reveal, however, is the rather remarkable variety and diversity of approach that teachers take to a common learning sequence or problem. The variety of emphases shown by the six teachers together with the lack of emphasis on certain of the concepts should be of interest to curriculum developers. If there were those who had felt that teachers would follow systematically the text, these results should certainly disabuse them of such a notion. No matter how the materials are organized and presented in a formal sense, it seems likely on the basis of the present data, that each teacher will plan the strategy of presentation and the emphasis on the basis of his own knowledge, interests, and perceptions of student need.

Teacher-Student Talk.

One of the functions of class discussion is to allow the student the opportunity to clarify his limited understanding of new concepts and enrich his conceptual field in the topics considered crucial by the teacher or as introduced by the students. As Schwab stated:

> Discussion of a certain sort is indispensable for the development of the intellectual arts and skills required to traverse a pathway of understanding. (1963, p. 430)

In addition, discussion can serve as a stimulus to greater motivation on the part of the student and encourage some student modeling behavior of the teacher. Accordingly, an attempt was made in the current analysis to discover the degree of student participation in the current classes.

The number of lines spoken by each student and the teacher were counted as they appeared on the tapescript. Total student line scores were obtained and these were translated into percentages for the purposes of comparison.

Table 5 shows the percentage of total teacher talk by topic classification and by class group. This figure was obtained by taking the total number of counted lines in the tapescript and dividing the number of lines attributed to the teacher. In total, the range of percentage of teacher talk extends from 66% in URIAH to a 95% in XAVIER. In general, overall classes there seems to be a consistent tendency for the teacher to speak from three to four times as much as the students. Teachers always seem surprised at the amount of talking they do compared with students.

In classes such as XAVIER with 95% teacher talk, and ZORBA with 89% teacher talk, the character of the classroom seemed more of a lecture punctuated by questions asking for short answers on the part of the students. In classes such as URIAH and VIRGIL the total percentage suggests that there is a discussion going on in the class session with significant pieces of interchange from the students.

Two statistical analyses were done on the data in Table 5. The first question asked was whether there was a significant difference between teachers in terms of the percentage of talk they do in

Table 5

PERCENTAGE OF TEACHER TALK BY TOPIC CLASSIFICATION

	STYLE CLASSIFICATION					
Classroom	Description	Explanation	Evaluation	Expansion	Total	H
URIAH	76	59	57	67	66	3.4
VIRGIL	78	73	60	72	72	1.4
WILLIE	81	83	91	87	83	4.7
XAVIER	97	91	100	100	95	---
YANCY	86	83	77	76	83	4.9
ZORBA	87	91	92	79	89	1.9
TOTAL	84	80	69	79	80	
H	14.24*	13.99*	7.77	11.55*		

*p < .05

topics of each Style classification. In all of the topics labeled Description, the percentage of teacher talk can be seen under this category for the six classes in Table 5. The range of teacher talk is from 97% in XAVIER to a low of 76% in URIAH. A Kruskal-Wallis, Non-Parametric Analysis of Variance, indicates that there was a significant difference between teachers in the amount of teacher talk per class in topics of this character. Similar levels of statistical significance were found in topics related to Explanation and Expansion. While there was a trend also on topics related to Evaluation, the results did not reach levels of accepted statistical significance. It seems quite clear on the basis of this and previous analyses that there were substantial differences in teacher style in terms of amount of student talk that takes place in the classroom and that these remain fairly consistent from one Style classification to the next.

A second analysis was done to see if the teachers show differences in their own style of response depending upon the kind of topic that was involved. The question asked was whether a teacher talked more in Description topics than in Explanation topics, or whether he encouraged more student participation in one type of topic than in another. Did the teacher change his style or strategy of approach depending upon the kind of topic that was being discussed? A Kruskal-Wallis Analysis of Variance was calculated, and in none of the sections was there a significant difference obtained. This lack of significance indicated that the teachers generally kept the same proportion of teacher-student talk regardless of the type of topic discussed. None of the teachers significantly changes their approach on the basis of the topic being discussed. In other words, they keep the same style throughout.

The overall portrait that is drawn here is that the teachers do the lion's share of the talking in discussion sections even to the point of almost complete lecture, there are substantial differences between teachers in terms of amount of student talk allowed in class

sessions, and teachers remain internally consistent in amount of talk allowed regardless of the type of topic discussed in the Style dimension of the classification system.

Expressive vs. Nonexpressive Students.

Another matter of concern to teachers revolves around the nature of the students who contribute substantially to class discussions. Are they really the topnotch students adding to their conceptual network by their questions and contributions or are they merely compulsive talkers who contribute to the discussion for a variety of social and motivational reasons only dimly related to scholarship? Another analysis done on the present samples of students was to compare a sample of the two extremes, the most and least expressive students. Expressiveness was defined as the amount of lines spoken in the final tapescripts. The top three boys and girls were chosen in each class on this basis. In one class the limited number of girls caused a choice of less than three.

The least expressive children were chosen by the same method. In some classes where there were more than three students who had zeros, which meant no verbal participation of any sort for the three days, the first three of these students were chosen for the nonexpressive sample on the basis of alphabetical order.

Table 6 shows the comparison of the most expressive versus least expressive students divided by sex. These groups were compared on measures of aptitude, performance on the BSCS test, a teacher-made test covering the unit in which the recorded material was included, and finally the teacher grade for the course.

On measures of aptitude the scores of the students were first transformed into standard scores in order to equate for the different tests used in the different school systems. This was done by transforming the scores into a mean of 100 and the standard deviation of 10. Thus a score of 120 on aptitude z score represents a mean of 2

TABLE 6

EXPRESSIVE vs NON-EXPRESSIVE STUDENTS

ON APTITUDE AND PERFORMANCE VARIABLES

BOYS

Variable	Expressive			Non-Expressive			t	p
	N	Mean	σ	N	Mean	σ		
Aptitude z Score	14	123.86	6.66	15	120.04	6.06	1.61	
BSCS Test	17	35.82	5.17	18	31.44	5.74	2.37	$<.01$
Teacher Test	17	3.29	.69	18	2.78	2.83	2.03	$<.05$
Teacher Grade	17	3.35	.86	18	2.83	.92	1.73	$<.05$

GIRLS

Variable	Expressive			Non-Expressive			t	p
	N	Mean	σ	N	Mean	σ		
Aptitude z Score	13	123.15	3.84	13	119.79	5.50	1.81	$<.05$
BSCS Test	15	34.53	4.69	17	31.24	6.95	1.58	
Teacher Test	16	3.12	1.02	17	2.53	1.23	1.51	
Teacher Grade	16	3.50	.82	17	2.82	1.24	1.88	$<.05$

standard deviations above the average. On the measures of aptitude there was a difference found between expressive and non-expressive girls at the .05 level of significance and the results approached significance for the boys. As expected, the expressive students showed more ability or aptitude than the non-expressive ones.

The most interesting finding of the BSCS test, which represented written proficiency in the area of biology was that there was a highly significant difference between expressive and non-expressive boys. There was also a difference in the same direction in favor of expressive girls which did not reach accepted levels of statistical significance. These results would seem to indicate that students who participate verbally in the class discussion were generally better students than those who did not participate. It is thus not a matter of students talking to hear themselves talk, but means that the students who are talking do seem to have a greater grasp of biological concepts as measured by the BSCS test than do those who remain silent.

On the teacher-made test the grades obtained by the student were transformed into a four point scale with four representing an A, three a B, etc. On the teacher-made test, there was again a significant difference found between expressive and non-expressive boys in the predicted direction for the boys, and again in the expected direction for the girls but short of statistical significance. As might be expected, the teacher grades parallel very closely the performance on the teacher test. Again, there were statistical significant differences in favor of the expressive students in both the boys and the girls.

These total results seem to support the notion that those students who showed the greatest degree of verbal expressiveness in class also show greater proficiency in the biological area as represented by teacher grades, tests, and objective BSCS tests.

BSCS Test Results.

Another analysis was completed on the performance of the six classes of students on the BSCS examination which covered the area under discussion in the present study, as well as a number of other topics not included in the present recordings. It represents the only achievement record on the classes that could allow for some comparison other than the typescripts.

Table 7 indicates the performance, by sex, of the groups. An analysis of variance test was calculated for boys and girls to determine whether there was significant variance between class groups. For the boys, an F score of 1.64 was obtained which was nonsignificant and indicated that there was no substantial difference between groups on the test.

For the girls, a different finding was obtained. An F score of 9.15 significant at the .01 level indicates that there was a substantial difference in performance between groups. An examination of Table 7 reveals that the girls in VIRGIL were substantially below the other groups in their average scores. The Newman-Keuls method of multiple comparisons (See Winer, 1962.) confirms this fact by establishing that the significant variance in the girls' samples was due entirely to VIRGIL's low position and that there were no other significant differences between any of the other groups of girls.

On this basis it would seem wise to conclude that except for some unexplained poor performances in one class group that the achievement as measured by this test was relatively uniform for the groups. Since the achievement was over a number of areas of biology and not just the concepts discussed in the present sample, too much cannot be inferred from this result. More to the point would have been an item analysis on test questions directly related to the present recordings but this data was not available to the present investigator.

In the context of these carefully selected honors classes, there appeared to be little choice between boys' and girls' performance

Table 7

PERFORMANCE OF TEST GROUPS ON BSCS TEST

	GIRLS			BOYS			TOTAL		
CLASS	N	$\bar{X}$	σ	N	$\bar{X}$	σ	N	$\bar{X}$	σ
URIAH	5	34.20	5.26	19	34.63	5.50	24	34.54	5.34
VIRGIL	13	23.85	6.27	8	29.75	7.69	21	26.10	7.27
WILLIE	9	31.0[illegible]	6.67	10	32.10	3.73	19	31.58	5.20
XAVIER	9	34.00	4.87	12	32.08	5.78	21	32.90	5.37
YANCY	4	35.00	3.37	13	33.46	6.12	17	33.82	5.54
ZORBA	12	37.25	3.59	14	35.64	3.17	26	36.38	3.41

on this test. Only in VIRGIL did there seem to be a striking difference and this has been discussed above. In three of the six class groups the girls averaged slightly higher scores than the boys.

Sex Differences.

In an earlier study, the present investigator (Gallagher, 1965) had noted that boys had apparently shown a higher degree of expressiveness in classroom interaction than had girls despite a lack of differentiation on written tests. This finding had been made with academically talented students from a variety of subject areas.

In the present study the total number of lines of typescript that were stated by girls was compared with the number of lines contributed by boys for each topic in each classroom. Table 8 shows the results of this analysis. In four of the six classes the boys were more expressive than the girls in a significantly greater number of topics. This method of analysis, which counted lines rather than individuals, did allow one sex even though outnumbered to produce a high score. In only one class, XAVIER, was there a tendency for girls to express themselves more than boys and it will be noted that this was the class where students rarely expressed themselves at length on anything. It will be noted that 34 of the topics showed neither girls nor boys were superior in XAVIER and in the vast majority of these topics neither boys nor girls said anything.

In two of the classes, URIAH and YANCY there were substantially more boys than girls and the results in Table 8 seemed to indicate that they completely overshadowed the girls under those circumstances. Even when the distribution of the sexes was more even, as in the other four classes, the tendency was still the same.

These findings should be viewed in connection with the results of the preceding section which indicated few if any differences between the sexes on written tests and teacher grades. These results, confirming the previous findings of this writer, suggest that girls are not inferior to boys in thinking ability but for some reason, which likely has a social-sex role basis, do not feel free to communicate ideas in the public forum of the usual classroom discussion.

Table 8

EXPRESSIVENESS BY SEX IN
CLASS DISCUSSION TOPICS

	Girls More Expressive	Boys More Expressive	Same	p
URIAH	5	40	11	$<.01$
VIRGIL	13	22	10	---
WILLIE	10	31	19	$<.01$
XAVIER	9	4	34	---
YANCY	1	47	11	$<.01$
ZORBA	9	19	19	$<.05$
TOTAL	47	163	104	

DISCUSSION

This study of instructional strategies in presenting the same set of biological concepts to six groups of high ability students yielded information along a number of different dimensions.

From an operational standpoint, this data would suggest that there really is no such thing as a BSCS curriculum presentation in the schools. Rather there is the URIAH interpretation of the BSCS curriculum, and the VIRGIL interpretation of that curriculum, and so forth. The substantial differences found in topics in terms of goals and levels of abstraction suggest that the teachers have different approaches in terms of instructional strategy that result in different ideas and concepts being presented to the students.

The actual biological concepts were presented with different emphases which seemed to relate to the interpretations and differing interests of the instructors. The instructor interested in the laboratory and its use in preparing future scientists will emphasize this aspect of the curriculum even in the discussion periods; the instructor interested in biochemistry will spend an unusually lengthy amount of time in that dimension while limiting his emphases on other points. Each teacher filters the materials through his own perceptions and to say that a student has been through the BSCS curriculum probably does not give as much specific information as the curriculum innovators might have hoped.

This is not a plea for the uniformity or a type of mechanical application of curriculum materials. It is often the excitement and uniqueness of interest of the individual teacher that stirs the student and commits him to seek similar adventure. These results do

have some implications in terms of teacher preparation, however. Most of the new curriculum movements have been impressed in their first contacts with content area teachers as to how deficient these teachers were in basic understanding of their subject area. Much of the emphases of the training programs were therefore centered on learning the 'new math' or the 'new biology' or what have you. Other instructional goals such as teaching for inquiry or stimulating creative abilities of students were given second place and presented, if at all, through the observation of a master teacher at work.

If these data are to be believed, such limited emphases on instructional strategy are not enough. Several of the present groups showed little in their discussion sections that resembled a substantial interchange of intellectual ideas between student and teacher and, in some, the emphasis on inquiry or searching was not carried from the laboratory to the discussion period. To obtain the goal of a vibrant discussion period most teachers must be taught the cognitive skills of how precisely to conduct a class discussion, or how to stimulate innovative approaches on the part of the student. Such teaching of instructional strategies has to be as explicit as the subject area teaching if one wishes the teachers to have similar competencies.

One area of greater emphasis might be placed upon instructional strategies on distinguishing between what can be expected from the public environment of the usual class discussion and what goals might be better obtained in the more private environment of teacher-student conversations, or the private exchange of written work by the student and the constructive response of the instructor. The present study revealed that girls tended to not participate in the public arena as much as the boys though achievement measures indicated that they were the equal of the boys in this regard. It is possible that effective communication with girls has to be done through the more private dimensions where the social aspects of the situation do not inhibit their performance.

In this study there was no question but that those students who were constant participants in class discussion were superior students to those who did not participate. They were not merely talking to hear themselves talk. They did reveal that they had an informational fund and the thinking ability to hold meaningful interchanges with the instructor. At the same time there was a substantial number of students in every class who were mute, or nearly so, in the three days of discussion. What lines of communication can be set up between the teacher and these students that can aid in their improving their comprehension of biological concepts?

In the absence of specific instruction and self analysis, most teachers teach as they were taught. It is an intuitive and rarely thought through skill. Occasionally, this intuitive approach yields an outstanding instructor. Just as occasionally a pharmacist mate or a nurse is a better practitioner of medicine than the doctor, but professions do not rely on such chancy happenings.

A substantial trend in teacher education has been in the direction of careful self analysis of one's own performance through study of videotapes or recordings using such tools as the Topic Classification System presented in this study. In this way, they can plan the kind of topics they wish to teach, the style in which they wish to present them and the level of abstraction at which they expect the work to occur. A reeximination of their performance, through analysis of their own performance, provides the medium through which instructional strategies can be effectively modified and through which such goals as increasing student inquiries can be systematically attained. It is in this dimension that one can increase teacher self awareness and allow the teachers to set their own goals without necessarily inducing a mindless conformity or uniformity of instruction.

Future Research.

Curriculum evaluation is a large term with many meanings. Most of the new curriculum projects have embarked on some efforts in this direction and more demands for systematic evaluation are sure to come as the increasing costs of such programs require justification. One type of evaluation has been to compare old and new curriculum across as many classes as one can control, and this sometimes can involve thousands of students. This investigator does not believe that such massive comparisons yield much information to the persons struggling to improve their curriculum programs. There are just too many variables interacting in the macrocosm of these many classrooms and different communities to allow for precise analysis.

Instead, the answer would seem to lie in clear delineation of the microcosm of the individual classroom observing as precise and limited goals as possible. In this way it is possible to see how different teachers present certain concepts and to test students on their understanding or ability to apply that particular concept. Surely there is a balance between complete freedom of the teacher to present whatever he wishes and the rigid curriculum that demands a slavish sequence. To establish the understanding of a system such as photosynthesis there should be some irreducible number of concepts that have to be introduced and interrelated. There may be more payoff in the intensive study of one brilliant student and his response to instructional strategies from one point in time to another than the global analysis of a thousand students over the course of a year.

Another potentially useful research strategy is to use the teacher as his own control and establish a baseline of instructional strategies for that particular teacher. This study pointed out that each teacher does have his own baseline for the amount of student

participation, for example. Systematic instruction could then be given to the teacher on how to develop Expansion topics, for example, and then measure the change in class performance and knowledge.

The ability to record and preserve teacher performance has opened up a wide vista of opportunities for the intensive study of instructional strategies and their immediate effect on students. They offer the opportunity for curriculum innovators to also record influence, over a short and reasonably controlled period of time, of their own interventions.

The results of this study have confirmed again that diversity is the central fact of human existence. In this case, the diversity of six competant teachers in their method of presenting the same curriculum materials. Such diversity may or may not have substantial influence on students but it would be surprising indeed if it did not. It would seem to suggest that those interested in curriculum development have not finished their job when they have packaged a cognitively valid and consistent set of materials. They must establish in addition how these materials are operationally introduced in the classroom environment. Otherwise they will be left with certain unjustified assumptions as to how their package is unwrapped in the classroom.

It is likely that the long range instructional goals of curriculum innovators will not be finally reached until they explicitly train teachers in techniques for analyzing their own instructional strategies as well as training them in their subject area fields.

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