DEVELOPMENT AND IMPLEMENTATION OF AN ENVIRONMENTAL EVALUATION AND REDESIGN PROCESS FOR A HIGH SCHOOL SCIENCE DEPARTMENT

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This paper examines the first year of activities of a project of environmental analysis and design being performed in the Science Department of Oak Grove High School, San Jose, California. This project is an attempt to develop a process by which environmental users may design, implement, and evaluate experiments in improving the fit of activities and environment to the tasks of teaching and learning.

Although this process is cyclical in the form described by James Boyce as "empirical evaluation" and shown diagrammatically in Figure 1 (1), this paper describes only the first phase. In this first phase the data base for future comparisons and for in use modifications to instructional programs and spaces was established. The cycling process is triggered whenever an experiment is prepared by the Science Department staff.

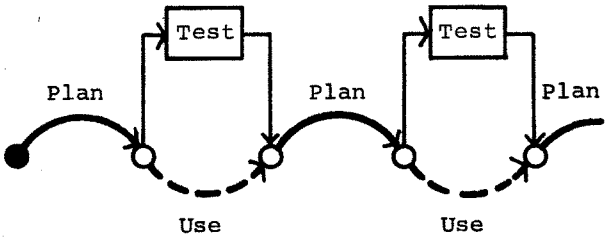


FIGURE 1. EMPIRICAL EVALUATION PROCESS

Background

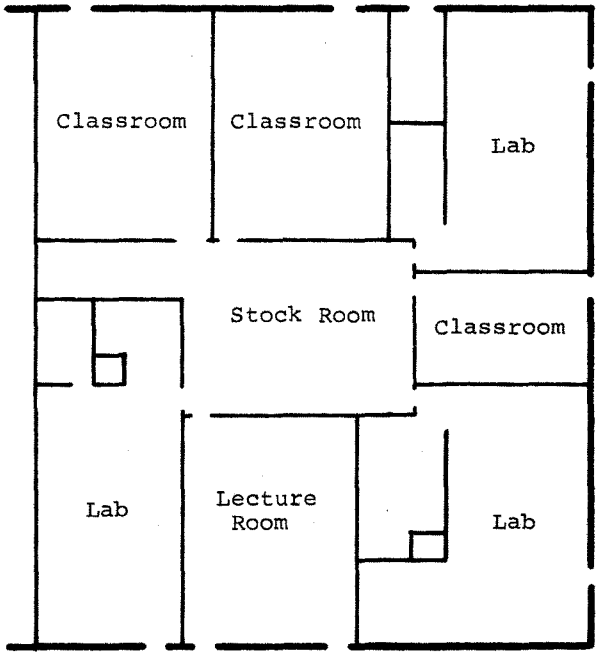
Oak Grove High School was one of ten secondary schools constructed under the School Construction Systems Development program (SCSD). SCSD, which was active from 1961 to 1967, developed an industrialized building system for use in school construction which provides flexibility in the physical components of buildings to respond to changes in educational programming and user needs (2). Oak Grove was designed by Allan M. Walter and Associates and placed in operation in September 1967.

In many areas of instruction, the school serves as a source of program and materials development for the Eastside Union High School District's nine schools. In this role, Oak Grove received a large grant from Kettering Foundation to develop and implement individualized instruction programs.

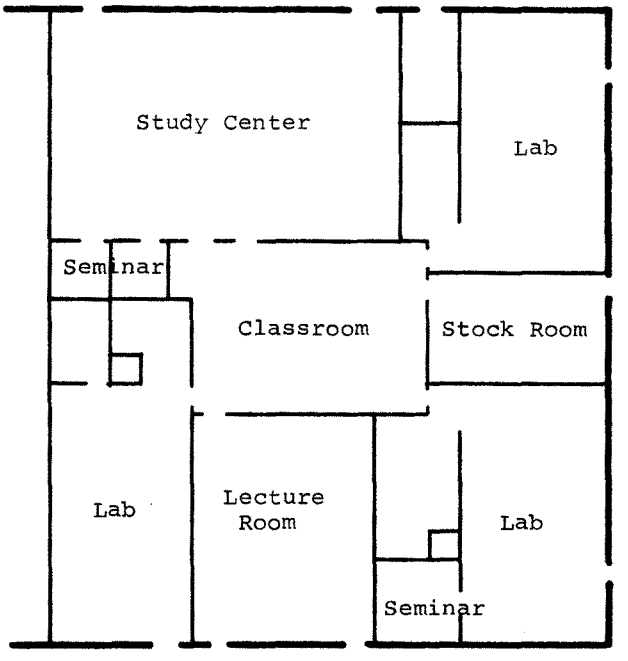
At Oak Grove, the teaching staff of the Science Department has been active in developing new curriculum and materials. This department began operations in a suite of classrooms and laboratories with a program calling for a conventional teacher-student relationship. In the past four years, the instructional program has been developed from this into an individual progress form of teaching with emphasis on the student as learner.

This evolution has required a rethinking of philosophy and roles, the development of new teaching materials, and the replanning of instructional spaces by the staff. The slow rate of materials development has paced this evolution in which two major spatial changes, corresponding to the completion of materials for freshman and for upperclass courses, have been made. These changes are illustrated in Figure 2.

While implementing these changes, the staff has constantly experimented with the spatial configuration and furniture layout of the suite, seeking better forms for their programs. At the completion of the development of the individual progress program, members of the staff felt that these experiments could be made more effective by application of a more formal methodology including better feedback.



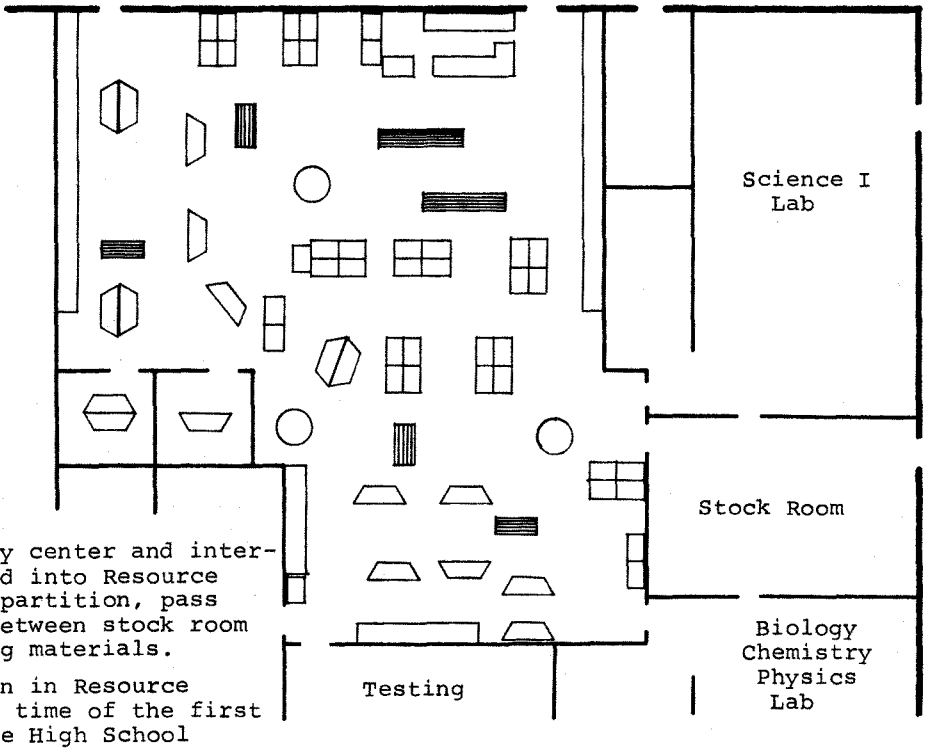
"Opening day plan" designed to house program of conventional teacher-student relationship.



First changes: study center created by removing partition between two classrooms, three seminar or small group rooms made with parts of removed partition and doors.

FIGURE 2

SPATIAL CHANGES IN THE SUITE OF THE SCIENCE DEPARTMENT 1967-1971



Second changes: study center and interior classroom combined into Resource Center by removal of partition, pass through windows cut between stock room and labs for obtaining materials.

Furniture layout shown in Resource Center is that of the time of the first phase of the Oak Grove High School Research Project.

Oak Grove High School Research Project

In the fall of 1970, the science department teaching staff approached the Building Systems Information Clearinghouse and the School Planning Laboratory of Stanford University with a request for assistance in gathering the data necessary to evaluate their programmatic and spatial experiments.

At that time, both of these organizations were involved in projects which related to the needs of the Oak Grove staff. The Building Systems Information Clearinghouse (BSIC), itself an outgrowth of the SCSD program, had been engaged in an evaluation of user response to the SCSD schools in 1969 and 1970. A group from the School Planning Laboratory (SPL) had been involved in a study of the effect of open space planning and programming upon the behavior and attitudes of teachers and students.

In October 1970, a group consisting of Mr. Arvel Clark, principal of Oak Grove High School, Mr. Jack Grube, co-chairman of the Science Department, Dr.Frank Brunetti of SPL, and Dr. John R. Boice and Mr. Joshua A. Burns of BSIC began meeting to develop the project. The study was christened the "Oak Grove High School Research Project."

As the project developed, these organizations were able to obtain the assistance and participation of other groups in various aspects of the study. To the present, a number of such groups have participated, including the Stanford Center for Research and Development in Teaching, the First California Commission on School Construction Systems, San Jose State College, and Lennox Industries.

Underlying Assumptions

Before proceeding to a discussion of the development of the project, some of the underlying assumptions should be made explicit. These assumptions were largely shared by the teaching staff and the study groups in the program. Although not formally stated during project development, they appeared often during the discussions of this period.

Underlying the entire study process is an assumption that a school is a "system"--composed of buildings, programs, materials, teachers, students, and other elements--the objective of which is the delivery of "education". In the functioning of this educational system, the interaction of elements may be of equal or greater significance than the elements themselves.

Likewise, the total environment in which learning takes place is composed of a great many interrelated elements--students, educational materials, environmental conditions, attitudes, teachers, and spaces to name a few. While each of these elements, and elements of each, may be studied independently, it is the totality of their interaction which creates the environment.

When the school is conceived as a system, it becomes clear that the school will be expected to respond to changes in both its external environment and in the elements or subsystems which compose the system. In this view, a school and its subsystems can be seen as a set of experiments working themselves out. The structure of the study is based upon this view of the school as an on-going experiment expressed by the teaching staff of the science department.

Objectives and Methodology

The original request made by the Science Department staff stated the problem with sufficient clarity to serve as the basic statement of project objectives. In this request, the staff sought to create a group which would collect data about environmental and behavioral conditions before and after the implementation of "experiments" in manipulating these conditions designed by the teaching staff.

In response to the project objectives, a methodology was developed which could be applied whenever the teaching staff was prepared for an experiment. The basic procedures of this methodology are:

(1) Statement of the objectives of the experiment by teaching staff; in the first phase, this consisted of a statement of the objectives of the Science Department's educational program.

(2) Conversion of these program objectives into measurable behavioral objectives.

(3) Measurement, observation, and survey.

(4) Analysis of this data including comparison of anticipated versus observed system behavior.

(5) Synthesis of results into (a) decisions about the experiment and/or (b) design criteria for program and spatial improvements.

(6) Implementation of action defined in (5).

(7) Iteration of steps (1) to (6) for each experiment.

Establishing a Data Base

In order to have a sound basis for evaluating future experiments, it was decided that the first iteration of these procedures would be the formation of a data base on existing environmental conditions, activity patterns and user attitudes in the Science Department. At the end of this process, in steps (5) and (6) above, alterations and corrections to improve the functioning of the Department would be made.

In February and March 1971, an intensive two week long series of measurements and observations were made in the department suite. These studies were followed up by surveys of students both at Oak Grove and at other high schools in the district. Following a brief discussion of the operations of the department at the time of the study, the key findings of these studies will be presented.

Department Operations

At the time of the study, the Science Department was housed in the suite illustrated in Figure 2. The heart of this suite, and the area of concentration for the study, was the Science Resource Center, a large open room in which most science related activities took place.

The department operated on a six period day with each period averaging fifty-five minutes in length. The average number of students in attendance in the department at the time of the study was 177 per period. Of this number, an average of 40 were in the two main labs and an average of 137 in the Resource Center.

The staff consisted of six certified teachers and three paraprofessionals who handled mechanical chores of the program, such as maintaining the library, distributing materials, taking attendance, etc. The schedule was organized so that five teachers were on duty in each period, one in each laboratory and three in the Resource Center.

Measuring Environmental Conditions

In the data base phase, measurement of existing environmental conditions was limited to three variables: noise levels, thermal environment conditions, and lighting levels.

The level of noise within the rooms of the department suite was measured by Bolt, Beranek, and Newman, Inc., Acoustic Engineers, on March 2, 1971. The results of these measurements for a typical class period in the Resource Center are presented on Figure 3. Figure 4 compares the noise level in the science department with that in other spaces in the school.

The results of these studies indicated that the noise levels in the Resource Center and the two laboratories were similar and, in both cases, of a level sufficient to be considered a major problem. The recommendation for improving conditions by this consultant was that the noise level problem could only be effectively reduced by a combination of improved room absorption and more effective teacher control of noise generation.

Thermal environment and lighting conditions in the Resource Center were found to be inadequate due to a failure by the school to change their configuration when the two spatial changes were made in the departmental suite (see Figure 2). The air-conditioning system while maintaining temperature within designed limits, had inadequate air movement patterns and the treated air had a very low relative humidity.

The lighting system was found to be potentially capable of providing required illumination levels throughout the Resource Center but was configured in an ineffective manner for the space use pattern. For both systems reconfiguration of fixtures was recommended. An alternative suggestion for the lighting system was to alter space use patterns to make better use of the existing lighting conditions.

With the exception of the noise level

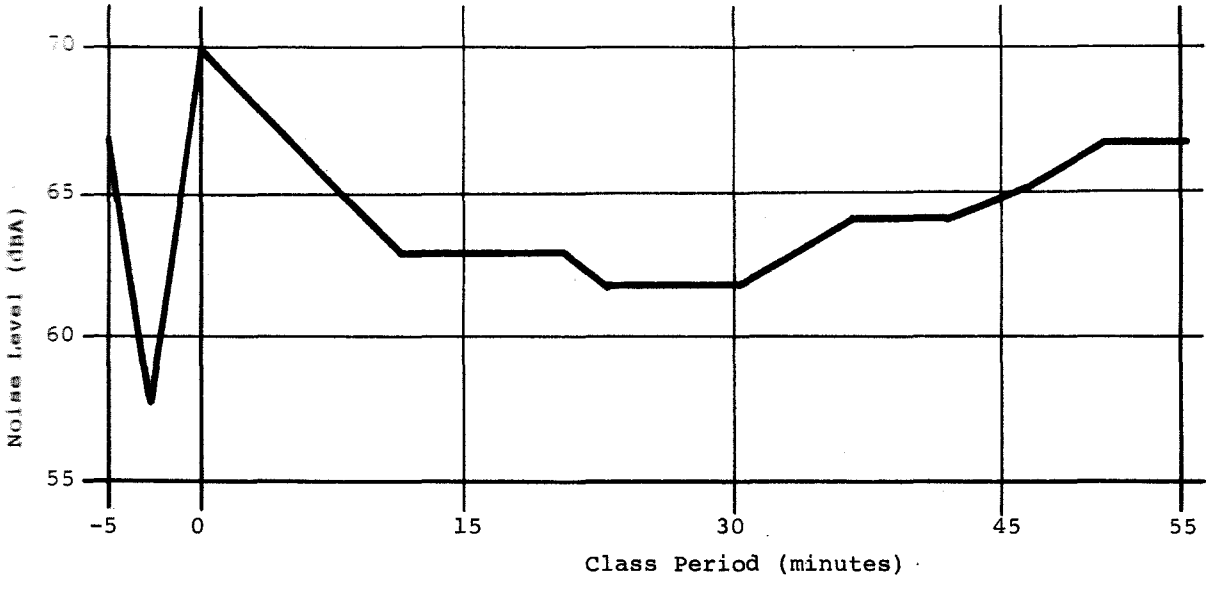


FIGURE 3

NOISE LEVEL IN RESOURCE CENTER DURING TYPICAL CLASS PERIOD

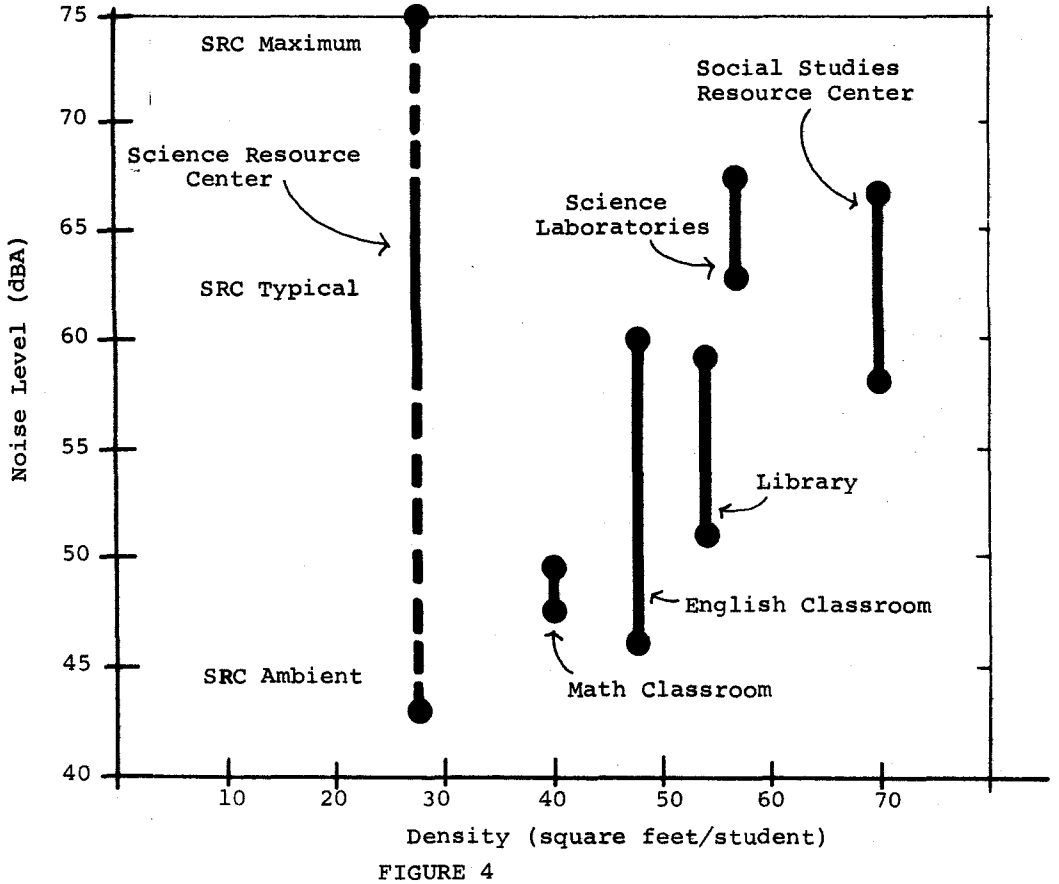


FIGURE 4

NOISE LEVELS AND DENSITIES IN VARIOUS SPACES

problems, environmental conditions in the laboratories appeared to be adequate. These spaces had not been altered in either of the two spatial changes and the use patterns were essentially the same as at the time of school opening.

Behavioral Studies

During the two week period of studies, a group of graduate students in education from Stanford University and San Jose State College led by Dr. Frank Brunetti made a series of mapping and observational studies. This group developed its observational format from a written statement of educational program objectives prepared by the department staff.

Emphasis in this program was on observing, recording and mapping grouping patterns and the types of activities engaged in by groups and individuals. The scope of the study included the Resource Center and the two laboratories. During the study, major furniture elements were fixed in location while chairs, etc., were allowed to be freely moved by students.

Both in this section and the following section on attitudes, a selection from the data gathered will be presented. The selection from behavioral data covers activities, group patterns, and the relationship between the two. While a great deal more data was gathered, these facets proved to be the most important in the data base phase of the study.

The observation group developed an activity coding used in mapping of seven activity categories which are listed on Table I. In analysing the results of activity mapping, the class period was divided into thirds. Table I presents the results for the Science Resource Center for the two laboratories combined.

A study of this table indicates that there is a much higher incidence of relevant (science oriented) activity in the two laboratories and that all activities in the labs are more stable throughout the period. A combination of factors -- greater direction of task, more teacher supervision, preference for manual tasks, and others -- probably influence this distinction.

Although the program is defined as individual progress, the majority of students observed worked in groups rather than alone, see Table II. Over time, the individuals and groups of two tended to be more stable in their relevant activity than did larger groups.

Attitudinal Studies

Dr. Brunetti's group also prepared and administered an "opinionaire" survey of student attitudes towards aspects of

TABLE I

PERCENTAGE OF STUDENTS ENGAGED IN VARIOUS ACTIVITIES DURING CLASS PERIOD

	Science Resource Center				Two Laboratories			
	Third of Period			Net	Third of Period			Net
Activity	1st	2nd	3rd	Change*	1st	2nd	3rd	Change*
Science Tasks	57.0%	54.6%	43.2%	-13.8%	75.3%	68.9%	72.3%	- 3.0%
Social Interaction	26.0	29.6	38.5	+12.5	7.2	14.3	13.6	+ 6.4
Teacher Interaction	4.0	3.7	2.8	- 1.2	4.9	6.9	2.8	- 2.1
Idle	5.1	4.4	6.9	+ 1.8	6.0	5.0	5.0	- 1.0
Other Subjects	3.3	3.4	3.9	+ 0.6	1.4	1.4	1.5	+ 0.1
Movement	4.6	4.3	3.9	- 0.7	5.2	3.6	5.6	+ 0.4

*Net Change = (Percentage in final third) - (Percentage in first third)

TABLE II

PERCENTAGE OF STUDENTS INVOLVED IN INDIVIDUAL AND GROUP ACTIVITIES AND MOVEMENT

Activity	Resource Center	Labs
Individual	42.3%	40.7%
Group	52.6	55.0
Movement	5.1	4.3

the program and the environment in the school and the Science Department. For purposes of comparison, the opinionaire was also administered at other high schools in the districts, the results have been presented elsewhere (3).

The problem of student distraction is a key issue in the study of open plan learning environments. At Oak Grove, more students (57.6 per cent) reported a high degree of distraction in the Science Resource Center than in either the labs (22.7 per cent) or in two spaces in the school which have similar open plans and programs: the Library (17.5 per cent) and the Social Studies Resource Center (17.6 per cent).

Table III presents student response on distracting factors in the Science Resource Center and the labs. A comparison of noise levels and student density (area per student) in these spaces is presented in Figure 4.

The study results have provided some insights into the problem of distraction in open space at Oak Grove. The results indicate that the type of activity causing the distraction and the activities of the respondent are closely related to the feeling of distraction. In addition, a relationship between student density and the amount of distraction due to noise levels has been observed.

Feedback

The data base formation phase of the study had two objectives: to establish the data base and to develop feedback upon which corrections and improvements in space and activities could be based. As a result, data analysis resulted in the development of criteria for modifying the instructional spaces and the activities of teachers and students.

A number of improvements were identified which were felt to be necessary for more effective functioning of the educational program. Briefly stated these modifications included improvement in environmental conditions, especially reduction of noise levels, greater control of grouping patterns and activities of students, and greater student-teacher interaction.

Financial considerations forced the postponement of three changes felt to be desirable: increasing room sound absorption in the Resource Center and labs, obtaining furnishings which would help control the size of groups, and developing moveable space dividers to provide a greater variety of spatial conditions. These modifications have been studied in detail and will be implemented as funds become available.

Making changes

In most cases, the recommended improvements in conditions required a combination of spatial alteration and increased teacher activity. Discussions between the staff and the study team of the results of the data base phase led to an understanding of what could be expected from various alterations and to a commitment by the staff to work with both space and their activities.

TABLE III

PERCENTAGE OF STUDENTS INDICATING A HIGH DEGREE OF DISTRACTION DUE TO SEVERAL FACTORS

Distraction Factor	Resource Center	Labs
General noise level	48.3%	23.4%
Presence of other students	36.4	24.1
Movement of other students	23.5	17.7
Conversation of other students working on science	24.2	16.2
Social conversation of other students	55.9	37.7

Spatial redesign was performed using a large scale model of the Resource Center and available furnishings prepared by BSIC. An afternoon was set aside upon which the staff and the consultants came together to design the new layout.

The teaching staff worked with the models to express various design ideas. The consultants evaluated the evolving designs which were periodically recorded with a Polaroid camera. Eventually a design satisfactory to the staff was achieved and implemented in the Resource Center.

Since implementing this redesign, the teachers have been increasing their interaction with the students. At the time of the first phase, the teaching staff had been intentionally keeping interaction at a minimum in order to assess the effects of the individual progress program and materials.

At the completion of the study the teachers agreed that a relatively high level of teacher/student interaction is necessary for the program to work at its best. In this respect, the findings of the study not only reinforced their feelings, but gave them valuable assistance in defining their new roles.

Conclusions

(1) The project appears to have been successful in achieving its objective of providing useable data to the Science Department staff.

(2) Working with the project has increased the teachers understanding of what goes on in the Science Department. One result of this is greater teacher confidence in guiding and controlling group formation and other student activities. A second result is an improved ability to communicate their goals and objectives in terms of what they desire to see happening (4).

(3) A number of factors which may affect the situation have been identified for further study, including long and short term effects of environmental conditions, the actual and the general problem of morale.

(4) In spite of the progress towards individualized instruction, the options available to the student and the teacher are still limited. The instructional spaces are sufficiently crowded to make selection of activities within the class period of the "musical chairs" variety. A student assigned to the Science Department during a class period must be present and under science teacher supervision. Finally, and justifiably in the light of the problems of curriculum development with a limited staff and resources, there are no real options except rate of progress in the instructional program.

(5) While scientifically sound, current methods of environmental and behavioral analysis are difficult to apply, expensive, and produce results which may be too precise for their purpose. New tools oriented toward quick and easy application and analysis must be developed.

(6) Current school budgeting procedures do not allow the tuning-up of a building when it opens nor do they permit evolution of spaces and environmental conditions.

Summary

The Oak Grove High School Research Project was undertaken in the fall of 1970 to provide the staff of the school's Science Department with better data for evaluating experiments designed to improve their program, activities, and instructional spaces.

In the year since the study was undertaken, the project has completed slightly more than one cycle of activities. A data base for evaluating future experiments has been formed. In addition the data collected in this phase has been used to evaluate behavioral and environmental aspects of the instructional program. As a result of this evaluation, improvements have been designed and implemented in both of these components of the educational system.

The assumption underlying this work has been that the school is a continually evolving set of experiments. By applying a more formal method, these experiments can be directed and harnessed to provide greater improvement in the school's role as a system delivering education.

Notes

(1) Boyce, James R., "What is the Systems Approach?", Progressive Architecture, November, 1969.

(2) Boice, John R., A History and Evaluation of the SCSD Project, 1961-1967, 1971.

(3) Brunetti, Dr. Frank, "Open Space: A Status Report", CEFP Journal, October,1971.

(4) Burns, Joshua A., Memo on meeting with Mr. Jack Grube, co-chairman of the Science Department at Oak Grove High School, (unpublished), November 4, 1971.