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ABSTRACT

Reported is a study designed to describe the nature of teacher-pupil-materials interactions occurring in classrooms using Australian Science Education Project (ASEP) materials and to investigate relationships between these interaction patterns, changes in student achievement and attitudes toward science in classes taught by teachers whose educational values, experience, and training differed. A Teacher Opinion Scale and a Teaching Practices Questionnaire were administered to a random sample of 68 teachers, 73 students undertaking the post-graduate diploma in education, and 16 ASEP members. Classroom interaction was analyzed using an instrument developed by the investigators, a Scheme for Analysing Behaviour in Individualised Classrooms (SABIC). Sixty-three videotaped lessons were analyzed. Correlations were computed between interaction measures and various outcome measures. Classrooms using ASEP materials were found to be inquiry oriented, with active student involvement. Among other findings was that of a strong negative relationship between teacher-materials interaction and student achievement, indicating that if the teacher is ill-prepared, essential materials are not readily available, and the teacher is unable to quickly pinpoint student difficulties and deal with them, class achievement suffers. (Author/PEB)

INTERACTION PATTERNS AND THEIR RELATIONSHIP WITH OUTCOMES IN AUSTRALIAN SCIENCE EDUCATION PROJECT CLASSROOMS

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INTRODUCTION

Whereas the past 15 years have been characterised by a great deal of interest in the teaching-learning process (c.f. Nuthall, 1968; Rosenshine & Furst, 1971; 1973), most of the research studies have concentrated on "conventional" classrooms where the teacher is the dominant actor. It is not surprising therefore that teacher activities such as "use of structuring statements", "use of pupils ideas", "level of questioning," and "use of a variety of procedures" are frequently found to be among the ones which are associated with pupil achievement (Rosenshine & Furst, 1971). However, we do not know whether these activities are associated with achievement in classes where self-paced curricula are used. Furthermore, there are many behaviors which occur in individualised lessons, but rarely, if at all, in conventional ones. Some of these may turn out to be significantly associated with pupil growth in individualised situations.

When self-paced curriculum materials are used what happens in science lessons is shaped, to a great extent, by the curriculum. The pupils' source books and record books guide the activities of individual students, small groups and, occasionally, the class as a whole. But curriculum materials are not the sole determinant of what happens in self-paced classrooms. How the materials are used

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depends very much on the teacher, on his educational values, training and experience. Pupils, too, will use and interact with the materials in varying ways depending on their ability, prior knowledge and attitudes towards science. In other words, there will be variations in the interaction patterns and classroom climate of classes using the same curriculum unit, and some of these variations will be related to variations in the extent to which the cognition and affective objectives of the unit are achieved.

In this study an attempt was made

(a) to describe the nature of teacher-pupil-materials interactions occurring in classrooms using Australian Science Education Project (ASEP) materials

(b) to study relationships between these interaction patterns, changes in student achievement and attitudes towards science in classes taught by teachers whose educational values, experience and training differed.

Methodology

The study described here represents part of a larger research project being carried out at the University of Queensland. The Queensland project, which is funded by the Australian Advisory Committee on Research and Development in Education, is designed to study the effectiveness of teaching activities in science classes using the Australian Science Education Project (ASEP) materials. These materials are designed to allow pupils to work in groups, to proceed at their own pace and to inquire and to discover for themselves. In the Queensland project twenty-one teachers and teacher trainees were asked to use a section of an ASEP curriculum unit entitled "Light Forms Images". The complete unit comprises a core of material which all pupils are expected to master plus a series of optional activities. Usually five teaching periods (of approximately 40 minutes each) are required to complete the core and 20 periods are allowed for the optional activities.

Initially a Teacher Opinions Scale (ASEP, 1973) and a Teaching Practices Questionnaire (Adams, 1970) were administered to a random sample of 68 teachers, 73 students undertaking the post-graduate diploma in education and 16 ASEP staff members. The data from these questionnaires were analyzed by using a principal components procedure followed by a varimax rotation to establish value dimensions, and the results were then used to establish clusters of individuals. Each cluster contained teachers whose value orientation towards teaching and science curricula were similar. The 21 teachers asked to use the core of the ASEP unit were selected so that several representatives of each cluster were included in the study. Thus the study included some teachers whose values were congruent with those of ASEP and others with dissonant values.

The experienced teachers remained with their usual Grade 9 class. The classes of the diploma students comprised ten to twelve randomly selected Grade 9 pupils. Three of the five lessons required for the core material were video-recorded, and the videotapes were analyzed using a classroom behavior coding scheme (SABIC) designed especially for this study. Achievement and attitude pre-tests were administered before teaching on the unit began and post-tests, including the Class Activities Questionnaire (Steele, House & Kerins, 1971), were administered during the sixth lesson. Data were obtained from 303 pupils, of which 150 were in the classes of the Dip. Eds. In designing the study, the authors were concerned the results be of both theoretical and practical significance. Discussions with ASEP staff and trial teachers revealed that they were very much concerned with determining the extent to which the ASEP environment should be structured. The classes of the 15 diploma students were allocated to three different treatments in an attempt to provide information relevant to

their concerns. The treatments were as follows:-

Treatment 1 : Additional Structuring.

The five classes in this treatment used the ASEP pupils' guide, record book and ancilliary equipment. At the beginning and end of each lesson the teachers led a class discussion on the salient points which had been covered previously and indicated those points which would arise in the ensuing lesson: that is, they involved the whole class in review and overview at the beginning and end of each lesson.

Treatment 2 : ASEP Materials

The classes in this treatment used the ASEP pupils' guide, record book and ancilliary equipment. Their activities were guided by the instructions in the curriculum materials and the teacher acted as a resource person.

Treatment 3 : Unstructured.

In this treatment the classes were supplied with all the equipment and aids necessary to study the concepts in the ASEP unit "Light Forms Images" but they were not provided with the pupils' guide or record book. The pupils were encouraged to explore on their own with the teacher acting as a resource person and, where appropriate, guide.

All diploma students were trained to use ASEP materials and to follow the treatment to which they were assigned. Those assigned to treatment 3 were familiar with the unit "Light Forms Images" and sought the same objectives.

Experienced teachers were allocated to one of two treatments, "trained" or "untrained." Trained teachers undertook an inservice program at the University of Queensland in which the objectives, rationale and possible strategies for the unit chosen were discussed.

A SCHEME FOR ANALYSING BEHAVIOR IN INQUIRY CLASSROOMS (SABIC)

A great many systems have been developed for classifying the behaviour of teachers and pupils in teacher-centered classrooms. In general, these systems appear to have limitations when one attempts to use them to describe the many and varied interactions between teacher, pupils and materials in inquiry-oriented, self-paced programs, such as the Australian Science Education Project. Indeed, the authors did attempt to use several of the existing schemes but found that none of these could be used in analysing interaction in A.S.E.P. classrooms without considerable modification. SABIC, a Scheme for Analysing Behaviour in Individualised Classrooms, grew out of these attempts.

Sampling Behaviour in Individualised Classrooms.

Anyone who has observed both teacher-centered and self-paced classrooms cannot help but notice the much greater complexity of the latter. In the teacher-centered classroom, most of the time, the teacher is interacting with a target pupil or pupils while the rest of the class observed: in self-paced programs, twenty or more interactions among teacher, pupils and materials may occur simultaneously. The observer if faced with the "cocktail-party problem", on who and what should one focus in a room buzzing with activity.

In collecting a video record of A.S.E.P. classrooms, two videocameras, three microphones and a control console incorporating audio and video mixers were used. Of the three microphones, one, a radic microphone, was placed permanently on the teacher, and the other two on each of two groups of pupils. At the beginning of a recording, cameras followed the teacher around and his microphone was turned up for the first three minutes. For the next three minutes, the focus was on one group, and for the next three, the focus was on another. Then back to the teacher for another three minutes during which time, the

remaining microphones were switched to another two groups. Subsequently, the behaviour of these groups was recorded, and so on.

Unit of Analysis

The basic unit of analysis in SABIC is the dominant behaviour observed observed during each ten second interval. A time rather than a functional unit was selected, because sampling the teacher and groups for three-minute intervals precluded the possibility of a continuous behavioural record.

Coding System.

Interaction between persons is essentially a process of communication. One can identify the source of a message or act, the person transmitting, and the target of the message, the person(s) to whom the message or act is directed. A message or act can be of several types - questions may be asked and information given during verbal interaction; students may write, experiment, observe, etc., in working through curriculum activities. Acts may fulfill one or more functions, and may be designed to contribute to the intellectual processes of the classroom instruction, non-instructional or affective processes. A listing of the classificatory categories with their respective codes appears in Table 1 below.

Table 1 about here

RESULTS (1) THE NATURE OF INTERACTION PATTERNS IN ASEP CLASSROOMS

A total of 63 videotaped lessons were analysed using the preceding scheme and the frequency of occurrence of each category determined. These frequencies are shown in Table 2. In interpreting the results, the procedure used in sampling teacher and student behavior needs to be kept in mind. Two-thirds of the time was directed to observation of student interactions with other students, materials, and, where relevant, the teacher. The remainder of the time was spent in observing the interactive behaviour of the teacher. In fact, most

of the time both sets of interactions occurred simultaneously. The proportion of time during which the teacher interacted with the class as a unit, giving directions, engaging in recitation and the like is given by the percentage of T-C interactions.

Table 2 about here

Table 2 also contains mean percentages of the various treatment groups. The observational data provides a check on the success of the treatments as well as valuable data in its own right. We find, for example, that the proportion of teacher-class interaction was significantly high for the additional structuring classes than the ASEP materials or unstructured groups. There was also a higher level of cognitive activity, less task irrelevant activity and more discussion of progress towards the unit objectives. On the other hand, in the unstructured classes students wrote less and experimented more. It would seem that the training procedures used were effective in producing the desired variations in behavior.

In training the experienced teachers, we did not intend to dictate to them how the unit "Light Forms Images" should be used. Our claim that we do not know which behaviours would prove effective in ASEP classrooms was perfectly honest one. We did, however, explain very carefully the rationale and objectives of ASEP; work through sections of the unit; view videotapes of teachers using other units; and engage in lengthy discussions about possible alternative strategies. There is some evidence to suggest that the training procedure was beneficial. In the trained teachers' classes, there was more group activity and experimenting; and there was less difficulty, less task irrelevant activity and less negative affect.

There were quite a number of similarities between the behaviour patterns in the experienced teachers' classes and in those of the science education students. For example, fact stating, explaining and questioning were low in both groups of classes. Experimentation, information-giving and direction-giving were common activities. Most information-giving served a descriptive function while the directions given generally related to procedures to be used in working through experiments and allied tasks. In all classes, praise, encouragement, sarcasm or extremes of criticism were rarely noted. Nevertheless, in the classes of science education students praise and encouragement were used more often and more consistently. Overall, the pattern of interactions in ASEP classrooms in Queensland stands in marked contrast to that observed in other Queensland classrooms (Tisher, Power & Endean, 1973). Whereas in conventional classroom, the teacher occupies a centre-front position 80-90% of the time and students experiment or interact with one another 10-20% of the time, the percentages are reversed in ASEP classrooms!

Table 3 about here

(2) RELATIONSHIPS BETWEEN SABIC MEASURES AND OUTCOMES

Using the class as the unit of analysis (N=21), correlations were computed between interaction measures and various outcome measures. The results are shown in Table 3. The pre and post achievement and attitude scales relate directly to the cognitive and affective objectives of the unit "Light Forms Images."

Among other things, we find that the more often an individual pupil (rather than a group of pupils, materials or the teacher) was the target of an interaction, the lower and more variable was student achievement. The frequency of teacher-materials interactions was negatively related to student achievement. Whereas

teacher-class interactions reduced variability in achievement, teacher-pupil interactions led to greater variability. The incidence of questioning and explaining was positively related to student attitudes, while observing, interpreting and the absence of activity were negatively associated with student attitudes towards the unit.

A usual assumption in research on teaching is that the associations between variables will be linear ones. But this may not necessarily be the case. Both Nuthall (1973) and Soar (1972) have recently reported the existence of curvilinear relationships between teacher behaviour and pupil growth. It was decided to begin a search for curvilinear relationships and for interactions between student characteristics and SABIC measures using the data obtained in this study. For the experimental classes, when their adjusted mean achievement and attitude scores were plotted against SABIC measures for the 21 experimental classes, a somewhat confusing set of graphs (72 in all) emerged . So far the results have not been particularly promising - the plotted means are scattered and generally any real or imagined curve is little better than a straight line. Even when tests for linearity of regression indicated that a non-linear relationship did exist and η^2 values were significant, we had doubts as to the meanings of the relationship. Also, we wish to add the information from our 1973 replication study to that of the present one. With more data clearer associations may emerge.

In one experimental phase of this study, the affects of structuring were examined. That training was, in fact, effective and has already been illustrated with the SABIC data. The behaviour patterns occurring in the classes with "additional structuring," classes using the "ASEP materials," and the "unstructured" classes were different. Both teachers and students were assigned at random to treatments. The self-paced nature of ASEP materials means that, by and large,

students are able to respond independently to treatments. Under these circumstances, it was argued that students could be used as the unit of analysis. A variety of two way analyses of covariance (e.g., treatment-by-teacher values) were carried out with the relevant pre test score as the covariate and several significant main and interaction effects detected. The concern in this paper is with the effects of interaction patterns and teaching strategies per se. As a detailed discussion of interactions of these variables with other variables of interest in the major study would convert this paper into an epic, only the main effects of the treatments are reported here. For a more detailed discussion see Tisher and Power, 1973.

Tables 4 and 5 about here

Significant differences between treatments were found for adjusted achievement scores but not for attitude scores. As the structuring of learning experiences by the teacher and curriculum materials is predominantly a cognitive enterprise, the result is not surprising. Contrasts among the treatments for adjusted treatments were made using the Scheffé Method. Contrasts revealed that treatment 1 (Additional structuring) was superior ($p < .05$) to treatment 3 (Unstructured) and that, on the average, treatments 1 and 2 were superior to 3 .

DISCUSSION

The evidence obtained in the descriptive phase of this study does suggest that the patterns of interaction in classes using the ASEP unit "Light Forms Images" is quite unlike that found in science classrooms using more conventional programs. A similar interaction pattern seems to characterise classrooms using other ASEP units and using other "individualised" programs like ISCS (Power & Tisher, preliminary data; Vickery, 1972). Both our observations and analysis

of data obtained from measures of student perception of the classroom environment indicate that such classrooms are inquiry oriented: students spend much more time experimenting, independently exploring and participating directly in classroom activities and far less as passive audience members. Also we find that there is far less emphasis on cramming, on grades and memorization. What happens in the average ASEP classroom tends to be congruent with the values of ASEP staff, the extent of congruence increasing when the values of the teacher are in harmony with those of ASEP and for when teachers are trained to use the materials (Tisher & Power, 1973). Overall, it seems that in ASEP classrooms, the teacher is no longer the remote provider and the students the dyspeptic receivers. New roles and new skills are demanded of the teacher.

While few associations were found between SABIC measures and student residual scores, the relationships obtained are intriguing. It will be interesting to see if they show up again in the replication study currently in progress in which we are studying the far more socially sensitive issues raised in a population ecology unit, "How Many People?" The results suggest that there was far greater variability in achievement in those classes where

(a) there was frequent teacher-pupil interaction and infrequent teacher-class interaction, and where

(b) correspondingly, pupils, and not the class, groups of pupils or materials were the target of interaction.

In other words, the more "individualised" and "personalised" an individualised classroom becomes, the more variable will be student achievement, and changes in student achievement. Also the more often interactions are directed at a single pupil (largely pupil-pupil, teacher-pupil interactions), the lower the overall

achievement of the class. Bearing in mind that the achievement measure used was basically a criterion-referenced one, the results provide a fertile ground for debate.

The results also indicate a strong negative relationship between teacher-materials interaction and achievement. It would seem that class achievement suffers if teachers spend much of their time looking for equipment, reading through the ASEP materials in an effort to determin what students should do next or as a preliminary to answering a student question. It would appear that in classes where teacher-materials interactions are common, the teacher is ill-prepared: essential materials are not readily available, and the teacher is unable to quickly pinpoint student difficulties and deal with them. Expressions of teacher and student non-involvement and disinterest (no activity, observation) are associated with negative attitudes while active task-oriented activity (questioning, explaining) is positively associated with attitudes The experimental phase of the study indicates that a certain amount of teacher structuring is needed to facilitate achievement.

In ASEP classrooms, the teacher is called upon not to teach but to create a viable learning environment. Rather than playing the role of a broadcasting station, the teacher must devote more time and thought to ways of stimulating interest; to initiating and managing the activities of groups and individuals; to guiding students and giving them help, directions and feedback if, and when, required; to ways of integrating the diverse experiences of individuals so that clear, stable and usable concepts and generalizations will emerge. /As conductor of the learning orchestra, the teacher must be responsible for the subtle blending of the notes from many instruments which produces a work of art rather

than chaos/. In this role, our results indicate that the teacher may need the same detailed knowledge of instruments (materials) and to the way in which the members of his orchestra (students) use them, as the conductor. Also, he must have a score: a grand plan which is sufficiently clear to give structure, meaning and purpose to activity, yet sufficiently flexible to allow for the talent and artistry of his students -- and he must explain the score to his students from time to time. Finally, the results suggest that learning orchestras do not play by themselves ... they do need a conductor who conducts.

TABLE 1: A List of the SABIC Categories

Source	1	Materials	Target	1	Materials
	2	Teacher		2	Teacher
	3	Class		3	Class
	4	Group		4	Group
	5	Pupil		5	Pupil
Act	1	Question	Act	5	Writing
	2	Follow-up question		6	Experimenting
	3	Information-giving		7	Observing
	4	Directions		8	Reading
				9	Multiple act.

Function

(a) Intellectual processes

1	Fact-stating	2	Describing
3	Interpreting	4	Explaining
5	Other cognitive		

(b) Instructional processes

1	Purposes	2	Procedures
3	Difficulties	4	Progress

(c) Non-instructional processes

1 Ignores

2 Does nothing

3 Task irrelevant

(d) Affective processes

1 + Emotional - praise, encouragement

2 - Emotional - sarcasm, discipline, criticism

(e) Other

TABLE 2

CORRELATION OF SABIC CATEGORIES WITH CRITERION MEASURES

SABIC Category	Criterion Measures *			
	Achievement		Attitude	
	Mean	S.Dev^{n}.	Mean	S.Dev^{n}.
Pupil as Target	-40	41		
Class as Target		-39		
Teacher-Materials Interaction	-61			
Teacher-Class Interaction		-41		
Teacher-Pupil Interaction		43		
No Activity			-43	
Questioning			40	37
Observing			-48	
Fact Stating				56
Interpreting			-46	
Explaining			63	
Procedures				51

* $r \geq 0.37$, significant at .05 level

* $r \geq 0.50$, significant at .01 level

TABLE 3: CATEGORY FREQUENCIES AS % TOTAL

SABIC Category	Sc. Ed. Students			Teachers		
	STR	ASEP	UNSTR	TRAIN	UNTR.	TOTAL
P Source	10	16	14	5	18	11
G	42	42	46	57	44	50
T	48	42	44	33	36	35
P Target	14	17	18	9	17	13
G	22	31	25	16	15	15
C	13	3	1	13	15	14
T	6	5	7	5	9	7
M	44	42	47	55	42	48
P-M	41	40	43	53	39	46
P-T	6	8	7	5	9	7
P-P	4	11	5	2	11	6
T-M	2	2	4	1	2	2
T-C	13	3	1	13	14	13
T-P	32	36	38	23	21	22
O Activity	4	5	4	5	6	6
Quest.	10	8	11	5	9	7
Inform.	16	12	17	8	15	11
Direct.	12	11	8	14	12	13
Write	5	4	1	4	6	5
Expt.	30	25	38	41	27	34
Obs.	8	19	10	14	11	13
Read	7	12	5	7	7	7
Q-A	7	4	5	2	10	6

TABLE 3 (Continued)

SABIC Category	Sc. Ed. Students			Teachers		
	STR	ASEP	UNSTR.	TRAIN	UNTR.	TOTAL
FAC	5	3	7	5	6	6
DES	13	6	13	4	14	9
INT	6	2	2	2	2	2
XPL	2	3	3	1	1	1
PRO	20	16	22	21	22	21
DIF	2	2	2	1	2	1
PRG	3	1	1	1	4	3
NTH	3	5	5	3	5	4
+ AFFECT	2	1	3	0	0	0
- AFFECT	1	1	1	0	2	1

TABLE 4: ANALYSIS OF COVARIANCE: ATTITUDE

Source	SS	Df	MS	F
Treatment	6466	2	3233	2.3
Error	2198	146	1402	
Total	8664	148		

Adjusted cell means: T_1 = -016; T_2 = -130; T_3 = 377

TABLE 5: ANALYSIS OF COVARIANCE: ACHIEVEMENT

Source	SS	Df	MS	F
Treatment	62	2	31.0	4.5*
Error	1013	146	6.9	
Total	1075	148		

* Sig at ~~α~~ - 0.025 level

Adjusted cell means: T_1 = 10.3; T_2 = 9.52; T_3 = 8.68

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