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ABSTRACT

Designed to describe students' perceptions within high school classes in biology and chemistry over the course of a school year, this study focused on person-environment congruence. Person-environment congruence was defined as the measure of the distance between high school students' perceptions of self and their science class, science teacher, and the subject studied. Four hundred and ten high school college preparatory science students responded to a questionnaire on attitudes toward and perceptions of the classroom environment. Responses revealed that student science attitudes became worse during the school year. Two thinking variables, one involving creative exploration and the other involving logical thinking, decreased, according to students' perceptions during the year. References are cited and five tables are provided. (ML)

Transactional Analysis of the Person-Environmental Interactions in High School Biology and Chemistry Courses Over a School Year

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TRANSACTIONAL ANALYSIS OF THE PERSON-ENVIRONMENTAL INTERACTIONS IN HIGH SCHOOL BIOLOGY AND CHEMISTRY COURSES OVER A SCHOOL YEAR

The purpose of this analysis was to describe student perceptions within high school classes in biology and chemistry over the course of a school year. The data reported in this paper were collected as part of a project on the improvement of high school science instruction. The project involved 44 science teachers of college preparatory biology and chemistry classes.

Theoretical Basis

Aside from the obvious differences in subject matter, most educators and researchers tend to regard high school science courses as similar to one another. They tend to speak of science teachers and science students as if they constituted relatively homogeneous groups of individuals and of science instruction as if it represented a distinct set of instructional strategies. While the content of earth science, biology. chemistry, and physics is known to be different, student-teacher interactions and process transactions are typically regarded as similar.

There is, however, some reason to doubt the similarity of process in different high school science courses. As a part of a large scale project to assess the effect of increased wait time and supportive intervention on high school chemistry and biology classes, researchers analyzed hundreds of classroom tape recordings. As they began the analysis process the research team was surprised to find that there appeared to be different characteristics of classroom interaction between the two science matter disciplines of biology and chemistry. This leads to the question: Are there qualitative differences in student perceptions of interaction patterns for biology and chemistry classes?

Pervin (1967) developed a strategy for testing the hypothesis that an individual's satisfaction and productivity in a given setting was a function of the congruence that existed between one's conception of the "self" and salient elements of that environment. In an initial test of the strategy, it was demonstrated that congruence was a predictor of college attrition, satisfaction, and academic productivity among undergraduates.

While Pervin's strategies have been applied primarily to the analysis of macroenvironments, there is reason to believe that they would be as useful in such microenvironments as a high school classroom (Dewey & Bentley, 1949; Pervin, 1968). Use of these measurement strategies in our study would be a logical extension of the work being carried on by researchers who are exploring the complex relationships between peer and individual attitudes toward science and the subsequent relationship to achievement (Hasan, 1985; Gardner, 1976; Lawrenz, 1975; Schell et al., 1986; Talton & Simpson, 1985; Taylor, 1974).

In this study, person-environment congruence was defined as the measure of the distance between high school students' perceptions of self and their science class, their science teacher, and the discipline they were studying. The purpose was to determine the extent and nature of the differences between high school biology and chemistry classes based on (a) student-environment congruence, and (b) a more direct measure of students' perceptions.

Procedure

The sample consisted of the responses of 410 high school college preparatory science students who were enrolled in 44 different biology and chemistry classes. Only those who completed all items at both testings were included in the analysis. The classrooms were located in 15 different school districts in central New York State.

Data were collected with a questionnaire distributed during a regular classroom period that students returned in a sealed envelope to assure confidentiality. The return rate was in excess of 75%. The data used in this analysis were from both the pretest and posttest of the larger study that had been gathered in order to assess changes that took place in perceptions over the duration of the school year. Two sections of the questionnaire data were used to measure (1) person-environment congruence, and (2) attitudes toward and perceptions of the classroom environment.

Person-environment congruence measures were based upon responses to four semantic differentials -- MYSELF, MY SCIENCE CLASS, MY SCIENCE TEACHER, and either BIOLOGY or CHEMISTRY -- on 12 identical bipolar adjective pairs: unattractive-attractive, simple-complex, weak-strong, purposeless-purposeful, calm-hyper, energetic-lazy, good-bad, leisurely-hasty, tender-tough, timid-courageous, trivial-important, and unreliable-reliable. Three measures of congruence were obtained by calculating the Euclidian distance between the perception of MYSELF and the other concepts in the twelve dimensional space defined by the bipolar adjective pairs. Distances were calculated by summing the square of the difference between the rating of each bipolar adjective pair on MYSELF and the target concept, and then taking the square root of the total. This procedure yielded three distances: MYSELF vs. TEACHER (MT), MYSELF vs. CLASS (MC), and MYSELF vs. BIOLOGY or CHEMISTRY (MSCI). The smaller the distance obtained, the greater the congruence or the person-environment fit.

Direct measurements of attitude toward science and perception of the classroom environment were made with 33 Likert-type items drawn in part from an attitude toward science scale developed by Talton and Simpson (1985), and from the <u>Classroom Activities Questionnaire</u> (CAQ). The CAQ provides a measure of student perceptions of their classroom environment (Steele, Walberg, & Kerins, 1971; Steele, Walberg, & House, 1974).

Perception-attitude items from both the pretest and posttest administrations of the questionnaire were subjected to a principal components analysis. Components with associated eigenvalues greater than 1.0 were retained, rotated to the varimax criterion, and used to form component scores (Table 1).

Insert Table 1 about here

The five components were identified as: science attitude (SA), creative exploration (CE), logical thinking (LT), student involvement (IN), and remembering information (RI).

The data were analyzed with a two-way multivariate analysis of variance (MANOVA) in order to explore the differences between direct perceptions and the person-environment congruence measures. There were two main effects -- class and time. Class [BIOLOGY or CHEMISTRY] produced a between-subject effect and time [BEGINNING or END of year] a within-subjects effect. The analysis was carried out with an SPSS/PC-X computer package (Norusis, 1986).

Results

The mean distances and perception scores by course and time are presented in Table 2. With the use of the Wilks' criterion,

Insert Table 2 about here

the combined dependent variables (DVs) were significantly affected by both course, $F(8,357)=4.174$, $p=<0.001$, and time, $F(8,357)=3.747$, $p<0.001$ (Table 3).

Insert Table 3 about here

To investigate the effects of each main effect and interaction on the individual DVs, a stepdown analysis was performed, on the basis of an *a priori* ordering of the importance of the DVs. Thus, each DV was analyzed, in turn, with higher-priority DVs treated as covariates and with the highest-priority DV tested in a univariate ANOVA.

Three of the variables had statistically significant stepdown *F*-ratios indicating their contribution to the differentiation of biology and chemistry students over time (Table 4). After correction for the effect of previously entered

Insert Table 4 about here

variables, class members were differentiated by their level of student-science distance (MSCI), creative exploration (CE), and remembering information (RI). With a cut-off of 0.300 for interpretation, the correlations between the discriminating variables and the discriminant function indicated that chemistry students tended to report higher student-teacher distances (*r* = 0.320), lower levels of remembering information (*r* = -0.618), and creative exploration (*r* = -0.556) than did biology students.

The results of the univariate tests and discriminant function analysis for the within-subjects main effect of time are presented in Table 5. The stepwise *F*-tests indicated that there

Insert Table 5 about here

were significant differences in perceived level of attitude toward science, creative exploration, and logical thinking over time. Correlations between the discriminating variables and the discriminant function indicated that the perceived levels of science attitude (*r* = -0.595), creative exploration (*r* = -0.494), and logical thinking (*r* = -0.409) decline in both classes over the course of the school year.

The changes in variables over time are shown graphically in Figures 1 and 2. Biology students are more likely to describe their classroom environment as one in which they must learn and remember considerable amounts of new information. More than

Insert Figure 1 and 2 about here

chemistry students, they believe they participate in discussions that develop new ideas. The congruence on the semantic differential indicates that biology students were more similar to their teachers than was true in chemistry. Students in both classes report a general decline in logical and divergent cognitive activities and in their attitude toward science as the school year progresses. The course by time interaction was not significant; students in both courses report changes of a pattern and magnitude such that their position relative to one another remained similar.

Conclusions

Two major types of differences were found in the student perception variables: those that relate to time and those that relate to the course being taught. Those that were affected by time included science attitude and the amount of perceived thinking involved with both biology and chemistry students. Science attitudes became worse during the school year. This type of finding has been noted in many other studies. Although it is not surprising, it is certainly not encouraging to see students liking biology or chemistry less as compared to their feelings at the beginning of the semester. Although it would have been encouraging to see the student attitudes become more favorable, having them remain at the same level would be an improvement over what actually does happen in many instances.

Two thinking variables, one involving creative exploration and the other involving logical thinking, decreased, according to the perceptions of the students, during the school year. To us it appears the students do not see biology and chemistry as being as open to multiple answers or as logical as they thought it would be three weeks after the semester had begun. Again, it would have been encouraging to see these two factors remain at the level perceived at the beginning of the academic year.

The three differences that were found between perceptions of chemistry and biology classes are also intriguing. The distance between myself and the course decreased in biology classes but increased in chemistry classes. Reasons for this are not easy to explain. Indeed, it may be only a chance difference. Creative exploration, which involves divergent thinking, was significantly different between chemistry students' perceptions and the biology students' perceptions with chemistry students indicating that lower levels of creative exploration occur in those classes. Our impression, from initial inspection of our large data base on classroom questioning, is that fewer divergent questions are posed by chemistry teachers. It may be that there is very little provision made in chemistry for students to explore alternative methods for solving problems and thinking about science.

The other significant difference between biology and chemistry occurs with the remembering information factor. This was no surprise. Whereas many of the correct answers in chemistry may be obtained by using logical thinking and problem solving techniques, the terminology load in biology class is forbidding. Students quickly learn that success is obtained by remembering large amounts of information. Until this memorization load can be reduced, students' perceptions of biology are likely to remain as little more than factual memorization.

Implications

In general, educators and researchers need to be more concerned than they have been in the past about structural as well as cognitive differences between science courses. Not only is the subject matter different, but the manner in which the students perceive and interact with the teacher and with each other is different. The idea of homogeneous "science students" may be as misleading as the idea of teaching a single "science" in high school.

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Table 1

Description of the Perception and Attitude Components in Terms of Sample Items with High Loadings

Component	Sample Item
Science attitude [SA]	I really like science.
Creative exploration [CE]	Inventing, designing, composing, and creating are major activities.
Logical thinking [LT]	Great importance is placed on logical thinking.
Student involvement [IN]	There is little opportunity for student participation in discussions.
Remembering information [RI]	Remembering or knowing information is the student's main job.

Table 2

Mean Values of the Dependent Variables by Class (subject studied) and Time of Testing

	BIOLOGY		CHEMISTRY	
VARIABLE	PRE	POST	PRE	POST
Distances				
MI	4.282	4.410	4.585	4.731
MC	4.111	4.159	4.301	4.412
MSCI	4.535	4.433	4.349	4.575
Perceptions				
SA	-0.011	-0.122	0.125	-0.047
CE	0.141	-0.044	-0.194	-0.290
LT	-0.021	-0.079	0.170	-0.019
IN	0.148	0.130	0.034	-0.061
RI	0.137	0.125	-0.186	-0.181

Table 3

Results of the Multivariate Analysis of Variance of the Main Effects of Class (subject studied) and Time of Testing and Their Interaction on Person-Environment Distance and Perceptions

Source of variation	Lambda	F	df	p
Between-subject effects				
COURSE	0.91447	4.174	8,357	<0.001
CONSTANT	0.05842	719.189	8,357	<0.001
Within-subject effects				
COURSE X TIME	0.98168	0.833	8,357	0.547
TIME	0.92253	3.747	8,357	<0.001

Table 4

Univariate and Discriminant Analyses of the Differences Between Students By Class

Total across time	F-test Univariate	F-test Stepdown	Discriminant Function d	Discriminant Function r
Distance				
MT	3.494	3.494	.182	.320
MC	2.257	0.020	.307	.257
MSCI	0.022	4.149*	-.419	-.026
Perceptions				
SA	1.258	2.206	.207	.192
CE	10.510***	6.829*	-.529	-.556
LT	2.050	2.644	.196	.245
IN	2.871	0.750	-.252	-.290
RI	13.020***	12.362***	-.642	-.618

* $p < 0.05$
** $p < 0.01$
*** $p < 0.001$

Table 5

Univariate and Discriminant Analyses of the Differences Between Students By Class Over Time

Difference between times	F-test Univariate	F-test Stepdown	Discriminant Function d	Discriminant Function r
Distance				
MI	2.131	2.131	.119	.264
MC	0.842	0.070	-.073	.166
MSCI	0.497	0.008	-.315	.125
Perceptions				
SA	10,828***	9.214**	-.650	-.595
CE	7.474**	8.172**	-.710	-.494
LT	5.105*	8.107**	-.561	-.409
IN	1.459	1.613	-.244	-.218
RI	0.004	0.100	.061	-.012

* $p < 0.05$
** $p < 0.01$
*** $p < 0.001$