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ABSTRACT

This research study investigated student perception of the social learning environment in biology, chemistry and physics courses. A stratified random sample of secondary schools from three regions was selected. The principal of each sampled school randomly selected a biology, chemistry or physics teacher who, in turn, randomly selected one of his classes to complete two instruments: Learning Environment Inventory (LEI); and the Test of Achievement in Science (TAS). The statistical procedures used were multivariate and univariate analyses of variance, and discriminant function analyses. Achievement level (high, middle, low) and science course (biology, chemistry, physics) were the two independent factors. The combined mean score for each science course on ten scales of LEI were the dependent variables. Results showed that there were significant differences between the students' perception of their environment in the three science courses. (HM)

Research Paper #12

Student Perception of the Classroom Learning Environment in Biology, Chemistry, and Physics Courses

Frances Lawrenz

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Student Perception of the Classroom Learning Environment
In Biology, Chemistry, and Physics Courses

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Several recent studies have reported a decline in student interest in science as a result of their participation in science classes (Ahlgren, 1969; Pella, 1969; Mackay, 1970; Kaphingst, 1971). The loss in interest appears more pronounced in the physical sciences than in the biological sciences. This suggests the possibility of a difference in the manner in which students perceive their biological and physical science courses. Possible perceptual differences were noted in an article by Robinson (1969) in which he proposed that physics and biology are separate entities which may have different perceptual impacts on children. The need for research to determine the extent and effect of these differences was pointed out by Shulman and Tamir in the Second Handbook of Research in Teaching. A study of these differences could perhaps provide insight into some of the problems encountered by science educators--namely, counseling, curriculum development, and student interest.

The purpose of this investigation is to examine student perception of the social learning environment in biology, chemistry, and physics courses. If any differences exist among the course perceptions, they will be examined in light of student loss of interest in science.

Procedure

The data were collected in March 1971 from a random sample of classes stratified on levels of population from three general regions, which included 12 states. These regions were the experimental and control areas for three National Science Foundation Comprehensive Projects. The principal of each sampled school randomly selected a biology, chemistry, or physics teacher who, in turn, randomly selected one of his classes to complete two instruments: Learning Environment Inventory (LEI) (Anderson, 1973), and the Test of Achievement in Science (TAS) (Lawrenz, 1972). In order to reduce test administration time, the testing was completed in one class period, utilizing the randomized data collection described by Walberg and Welch (1967). The student instruments were ordered before being mailed to the teacher to insure a random distribution within each class.

The LEI has been shown to be a discriminating measure among secondary school students, both within and between courses (Anderson, Walberg, and Welch, 1969; Yamamoto, Thomas, and Karns, 1969; Anderson, 1971). The form of the LEI used here contained ten scales related to classroom social situations. A description of each scale along with its reliability is given in Table 1. Each item was scored 4-1 for a strongly agree, agree, disagree, and a strongly disagree response. Some items were reversed scored to reduce response bias. A high score indicates agreement with the scale.

The TAS, which contained items pertaining to biology, chemistry, and physics courses, has a Kuder-Richardson #20 reliability of .87. It is a 45-item, six-option, multiple choice test compiled from the items released for public use from the National Assessment Test for Science. A measure

TABLE 1

LEI Scales

Description	Internal Consistency Alpha
Diversity -- the extent to which the class provides for a diversity of student interests and activities.	.53
Formality - the extent to which behavior within the class is guided by formal rules.	.76
Friction - the extent to which conflict exists among the students in the class.	.72
Goal Direction - the extent to which the goals of the class are recognized by its members.	.85
Favoritism - the extent to which differential treatment of students exists in the classroom.	.78
Difficulty - the extent to which the work of the class is perceived as difficult.	.64
Democratic - the extent to which all students participate in class decisions.	.67
Cliqueness - the extent to which cliques are present in the classroom.	.65
Satisfaction - the extent to which students are satisfied with the class.	.79
Disorganization - the extent to which the class is perceived as disorganized.	.82

of achievement was included because stratification by achievement helps to insure group comparability, increases the power to detect differences, and allows for the detection of interactions.

Analyses were carried out to answer the following questions: (1) Are there any overall perceptual differences among the science courses? (2) What specific components of the environment are perceived differently? (3) Do these specific components differentiate between each pair of courses? and (4) Can the specific components considered as a group be ordered on the basis of their ability to discriminate among the courses? The statistical procedures used to test null hypotheses associated with the above questions were (1) multivariate, and (2) univariate analyses of variance, (3) Newman-Keuls multiple comparisons, and (4) discriminant function analysis, respectively. The ten scales of the LEI served as the dependent variables. Achievement level--high, middle, and low (based on class mean scores on the TAS within each science course)--and science course--biology, chemistry, and physics--were the two independent factors in the design.

Results

Overall differences were tested based upon F-statistics from a multivariate analysis of variance. The results of this analysis, presented in Table 2, showed that the hypothesis of no multivariate difference could be rejected ($p < .01$), so that there was a significant difference between the students' perception of their environment in the three science courses. Because there was no significant interaction ($p < .26$) between achievement level and type of science course, achievement level and type of course were considered to be independent.

TABLE 2

Multivariate F-Statistics for Achievement Level by Type of Course

Source of Variation	F-Ratio	P Value
Achievement*	2.71	< .01
Class*	11.18	< .01
Achievement x Class**	1.14	.26

*d.f. = 20 and 440

**d.f. = 40 and 836

Because the multivariate analysis produced significant results, the univariate F-statistics were examined. This procedure tested for possible differences among the science courses for each LEI scale. As shown in Table 3, nine of the ten LEI scales revealed significant differences among the courses. The combined mean scores for biology, chemistry, and physics classes on these nine scales--Diversity, Formality, Friction, Favoritism, Difficulty, Democratic, Cliqueness, Satisfaction, and Goal Direction--are presented in Table 4. Biology classes were rated highest, then chemistry, then physics on the Diversity, Formality, Friction, Favoritism, Cliqueness scales. Chemistry classes, followed by physics and then biology classes, were rated as highest on the Difficulty scale and lowest on the Disorganization scale.

To investigate further those scales for which the univariate analysis indicated a significant difference among the science courses, Newman-Keuls multiple comparisons were made on the combined course means. Multiple comparisons are techniques for identifying significant differences among a set of three or more means. The Newman-Keuls method can be used to do all possible simple contrasts with good power (Hopkins, 1972). The means of the levels for the factor considered are ordered, and the q-value for a desired alpha level is dependent on the number of means between the two being compared. The two means with the largest difference between them must be considered first, then the two means with the second largest difference, and so on, resulting in q_1, q_2, and q_3 values.

For the combined course means, there were three contrasts of interest: biology with physics, biology with chemistry, and chemistry with physics.

TABLE 3

Univariate F-Statistics for Type of Course

Variable	M.S.	M.S.Error	F-Statistic	P Value
Diversity	.18	.02	9.10	< .01
Formality	1.15	.05	20.83	< .01
Friction	3.58	.09	41.66	< .01
Goal Direction	.0001	.09	.001	< .99
Favoritism	1.40	.07	19.22	< .01
Difficulty	2.09	.04	45.	< .01
Democratic	.11	.02	6.52	< .01
Cliqueness	.84	.07	12.30	< .01
Satisfaction	.40	.10	3.99	< .02
Disorganization	.43	.14	3.14	< .05

d.f. = 2,229

TABLE 4

Combined Course Mean Scores

	Diversity	Formality	Friction	Favoritism	Difficulty	Democratic	Cliqueness	Satisfaction	Disorganization
Biology	2.91	2.67	2.57	2.16	2.63	2.45	2.73	2.51	2.32
Chemistry	2.84	2.62	2.25	1.99	2.92	2.48	2.60	2.57	2.18
Physics	2.81	2.39	2.13	1.86	2.87	2.54	2.49	2.68	2.24

The results of these contrasts are defined and presented in Table 5. All of the q_1 contrasts were significant at the .01 level. All of the q_2 contrasts were significant at the .01 level except for the Favoritism and the Democratic scales. Only two of the q_3 contrasts were significant at the .05 level--Friction and Cliqueness. Therefore, only these two scales successfully discriminate among all three classes.

In order to investigate more carefully the contribution of each scale, a discriminant function analysis was completed. Discriminant analysis is a method for determining a linear combination of predictor variables that shows large differences in group means for each factor (Tatsuoka, 1971). Each scale is weighted by an appropriate coefficient. Once these coefficients are standardized, the scale with the highest coefficient can be considered as the scale that discriminates best among the factor's levels. The scale with the second highest coefficient discriminates second best, and so on. The analysis produced significant results at $p < .01$, so it was possible to order the LEI scales. The coefficients for the type-of-science-course factor are presented in Table 6. The best discriminating scales for course effects were Difficulty, Friction, and Formality.

The results of the discriminant analysis should be considered in light of the results of the univariate analysis. Most of the differences between these two analyses seem to be due to the interscale correlations which were utilized in the discriminant analysis but not in the univariate ones. For example, of the two scales that were shown to be the best discriminators for course effects by the Newman-Keuls analysis--Friction and Cliqueness--only one, Friction, appeared high in the discriminant analysis. This seemed

TABLE 5

Newman-Keuls q-Statistic for Combined Course Means

	Diversity	Formality	Friction	Favoritism	Difficulty	Democratic	Cliqueness
Physics with Biology	$q_1=5.4$**	$q_1=8.9$**	$q_1=11.2$**	$q_1=4.5$**	$q_2=8.5$**	$q_1=5.0$**	$q_1=6.7$**
Chemistry with Biology	$q_2=4.7$**	$q_3=2.2$	$q_2=10.7$**		$q_1=13.3$**	$q_3=2.2$	$q_2=4.8$**
Chemistry with Physics	$q_3=1.9$	$q_2=7.6$**	$q_3=3.2$*	$q_2=2.5$	$q_3=1.8$	$q_2=3.6$	$q_3=3.2$*

**siq at $P<.01$

*sig at $P<.05$

TABLE 6

Discriminant Function Coefficients for Type of Course

Variable	Standardized Coefficient
Diversity	.15
Formality	.45
Friction	.52
Goal Direction	.19
Favoritism	.10
Difficulty	-.69
Democratic	-.20
Cliqueness	-.04
Satisfaction	-.21
Disorganization	-.27

contradictory, but an examination of the interscale correlations in Table 7 showed that Cliqueness was correlated with Friction. Since the two scales were related, the discriminant analysis selected the one that discriminated best.

Summary

There were significant perceptual differences on nine of the ten LEI scales: Diversity, Formality, Friction, Favoritism, Difficulty, Democratic, Cliqueness, Satisfaction, and Disorganization. The Goal Direction scale did not show significant perceptual differences. Usually the greatest difference in perception was between the biology and physics students, with the chemistry student course perception scores lying between. This trend held for seven of the nine scales. For the remaining two significant scales, the greatest difference was between chemistry and biology classes, with physics classes in the middle. Because of the large differences in student perceptions of their science courses, researchers in science education must be extremely careful about considering physics, chemistry, and biology together as science in the same ways.

Among the three courses, biology classes were perceived by students to be diverse and usually controlled by strict rules that were determined without student consultation. There was probably an extensive subgroup culture within the classes with corresponding friction and differential teacher response. The course was viewed as the least difficult among the sciences.

Chemistry classes were perceived by the students as the most difficult and the least disorganized. The classes were viewed as somewhat diverse with fairly strict rules and little student consultation on decisions. There was some subgroup culture and apparent differential teacher response but little friction.

TABLE 7

Correlations Between LEI Scales

	Diversity	Formality	Friction	Goal Direction	Favoritism	Difficulty	Democratic	Cliqueness	Satisfaction	Disorganization
Diversity	1									
Formality	.04	1								
Friction	.20	-.10	1							
Goal Direction	-.09	.38	-.44	1						
Favoritism	.05	-.05	.63	-.49	1					
Difficulty	-.03	.26	-.18	.04	-.07	1				
Democratic	-.11	.19	-.37	.47	-.45	-.07	1			
Cliqueness	.34	-.06	.54	-.19	.34	-.11	-.21	1		
Satisfaction	-.10	.24	-.49	.71	-.55	-.03	.49	-.23	1	
Disorganization	.10	-.45	.60	-.74	.58	-.21	-.42	.39	-.70	1

Physics classes were perceived by the students as being fairly cohesive with little friction or teacher favoritism. The classes did not have strict rules and the students had a voice in the decisions. The course was viewed as being almost as difficult as chemistry with a little less diversity, and was viewed as most satisfying among the three courses.

The discriminant function analysis ordered the LEI scales on the basis of their ability to discriminate among the science courses. Those scales that discriminated best were Difficulty, Friction, and Formality.

Discussion

One purpose of this investigation was to provide descriptions of the different environments that were perceived within the individual science courses to provide an aid to counselors and in curriculum development. Counselors will now be able to describe for students the nature of the environment likely to be found in biology, chemistry, and physics classes. This information should be valuable to the student in the selection of his courses. Course descriptions resulting from knowledge of student perception of the usual environment in biology, chemistry, and physics courses can be used in attempts to revise science courses to produce desired perceptual changes.

Another purpose of this investigation was to examine the results in the hope of shedding some light on the loss of interest that occurs in biological and physical science courses. Examination of those scales that were shown to be the best discriminators by the multiple comparisons and the discriminant function analysis would probably be most fruitful. The Newman-Keuls q-statistics revealed that, while seven scales discriminated between biology and physics classes, only two scales, Friction and Cliqueness, successfully discriminated among all three courses. The discriminant function analysis selected the Difficulty, Friction, and Formality scales as the best discriminators among the three courses.

The Difficulty scale seems to provide the most logical explanation of interest loss. The physical science courses are viewed as much more difficult than the biology courses, even though the physical sciences usually have a more select group of high ability students. Many people tend to lose interest in things they find particularly difficult. Students usually prefer courses which are less difficult and in which they can excel. Some way should be found to present physical science material in such a way that students will find it easier and therefore less threatening. One way to accomplish this, at least for some students, would be to cover the science concepts and principles with less emphasis on the related mathematics. Students often can understand the physical science concept but are unable to handle its mathematical interpretation.

One possible effect of the presence of an extensive subgroup culture in the biology classes, as evidenced by the high Friction score, could be the creation of a cooperative class situation. It has been shown that students prefer cooperative classroom situations (Johnson, 1973). The subgroup members of biology classes could be working together rather than each student working alone and competing with the other students as is likely to occur in physics classes. It is also possible that in biology class the subgroup members cooperate among themselves while they compete with the other groups, thus, combining aspects of both the competitive and the cooperative learning environments.

In summary, then, it may be possible to make physical science classes more interesting by encouraging a cooperative subgroup structure with inter-group competition and by presenting scientific concepts in the simplest manner possible. Care must be taken in implementing these changes to insure that the achievement level of the classes is not subsequently lowered.

There are two areas in which further research could be completed. A longitudinal study which would follow the biology students through chemistry and physics and measure their perceptions of each learning environment to determine (1) if these perceptions match those obtained in this study, and (2) if the differences in perceptions of biology, chemistry, and physics classes would still exist even though the same people would do the rating. Another study could be completed to determine if student perceptions of the learning environment change while the student is enrolled in the particular course. If differences do exist, they may be contributing to the reduced student interest that occurs upon course completion.

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