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Reported is a comparative study on the attitudes of physics and chemistry students in high schools toward science, scientists, science teachers and "myself as a scientist" compared with those of students who had taken neither course. A semantic differential test, a sentence completion test, and a word association test were used in the test battery. Findings included the following: (1) students who took physics and chemistry demonstrated more favorable attitude toward science, science teachers and "myself as a scientist," (2) girls demonstrated more favorable attitudes than boys toward scientists and science teachers, (3) boys demonstrated more favorable attitudes than girls on "myself as a scientist," and (4) no significant differences were detected between boys and girls toward science. (GR)

TEST EVERY SENIOR PROJECT

ATTITUDES OF SENIORS CONCERNING SCIENCE

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Introduction

Attitudinal outcomes are frequently mentioned in statements of objectives of curricular offerings. A favorable attitude toward the subject, along with some of the institutional values held by professionals in that discipline, are common attitudinal objectives found in curriculum guides and teacher handbooks. Generally, attitudinal objectives are poorly defined and, consequently, their attainment is difficult to measure.

In attempting to specify the meaning of attitude, Shaw and Wright extracted commonalities from definitions in several major works. They concluded that an attitude is "a relatively enduring system of evaluative, affective reactions based upon and reflecting the evaluative concepts and beliefs which have been learned about the characteristics of a social object or a class of social objects."[1] Two educationally significant features of attitudes specified in this definition are:

1. their enduring character, and
2. that they are learned.

Another feature of attitudes which is explicit in the definitions reviewed by Shaw and Wright but only implicit in their definition is that attitudes constitute a predisposition to behavior.[2]

Since attitudes are learned enduring predispositions to behavior, students' attitudes toward science may be reflective of their school experiences in science classes, and may also influence future actions such as career choice and willingness to be supportive of science. Therefore, it was decided that assessment of high school seniors' attitudes toward science would be an appropriate part of Test Every Senior Project. Data derived from this portion of the survey would provide an indication of the current status of student attitudes toward science as they are related to specific student and curricular variables.

Work on measurement of high school students' attitudes toward science is limited. Snow and Cohen[3] examined attitudes of graduate and

undergraduate college students toward the sciences and the humanities. Lowery[4] studied attitudes of elementary pupils toward science. Wick and Yager[5] explored student attitudes in science courses at the Laboratory School of the University of Iowa. Rothman, Welch, and Walberg[6] studied attitudes of physics students in relation to physics teacher characteristics. None of these studies measured attitudes toward science of a broad population of high school students. The Project TALENT[7] sample satisfies the foregoing criticism. However, interests, not attitudes, were examined. The National Assessment[8, 9] does focus on attitudes toward science. When these data become available, they will provide interesting comparisons with data from this study.

Instrumentation

A battery of attitude tests were compiled by Gallagher[10] and field tested on a variety of student populations. The battery consisted of three parts:

1. a semantic differential test in which students evaluated 10 concepts (social studies, mathematics, science, observing, experimenting, scientists, science teachers, teachers, myself, and myself as a scientist) in terms of sixteen bi-polar scales. These bi-polar scales were classified into four categories--evaluation, potency, activity, and personality.[11] A five-point differential was utilized on all scales.

2. a sentence completion test, modeled after that developed by Lowery,[12] comprised of four sets of statements each containing a neutral, a positively oriented, and a negatively oriented statement. As with Lowery's test, one set of statements dealt with scientists, one with science, and one with the processes of science. A fourth

set of statements, which was used as an introductory or practice item, asked students' plans after high school.

3. a word association test consisting of three non-science-related "practice items," fourteen science-related items (e.g., data, hypothesis, prediction) and two "institutional" items (learning, school). Three responses were solicited for each of the nineteen items, since Lowery[13] found that this provides more easily interpretable information.

Procedures

The Science Attitude Scales battery was administered to a random sample of the Test Every Senior Project population as described in another paper (N=1626).[14] Semantic differential tests were machine scored and information transfered to a data-processing card format for subsequent analysis. Sentence completion tests were read by trained raters. Student responses were categorized according to a classification scheme based on pilot studies of this test. Data from the Word Association Test are currently being analyzed.

Information generated as part of Test Every Senior Project is being used as a data bank. As issues are raised, hypotheses can be formulated and tested using these data. This procedure was applied to the results from the Science Attitude Scales battery.

In this paper two general issues have been raised about student attitudes toward science. Several hypotheses related to each of these were stated and tested. The first issue concerns the relationship of attitudes toward science and the courses which students have taken. The second issue concerns attitudinal differences between boys and girls. In this paper, analysis will be limited to student responses to four concepts of the semantic differential test: science, scientists, science teachers, and myself as a scientist.

Hypotheses

Issue 1

In comparing semantic differential responses of students who have taken physics and/or chemistry and those who have taken neither course, it was hypothesized that the former group would respond more favorably to the following concepts:

1. science,
2. scientists,
3. science teachers, and
4. myself as a scientist.

Issue 2a

In comparing semantic differential responses of boys and girls who have taken physics and/or chemistry, it was hypothesized that differences would be found in their responses to the following concepts:

1. science,
2. scientists,
3. science teachers, and
4. myself as a scientist.

Issue 2b

In comparing semantic differential responses of boys and girls who have taken neither physics nor chemistry, it was hypothesized that differences would be found in their responses to the following concepts:

1. science,
2. scientists,
3. science teachers, and
4. myself as a scientist.

Results

Student responses to each of the semantic differential concepts were assigned integral values ranging from one point for the least favorable response (e.g., boring or worthless) to five points for the most favorable response (e.g., interesting or valuable). Since each of the categories, evaluation, potency, activity, and personality, was comprised of four bi-polar scales, an average score for each category was determined for each student. Thus, on each concept, a student received four scores ranging from one to five points, one for evaluation, one for potency, one for activity and one for personality. Since four concepts (science, scientists, science teachers, and myself as a scientist) are considered in this paper, sixteen different scores are being analyzed.

Students were grouped by sex and according to whether or not they had studied physics and/or chemistry. Thus, four groups were established: boys with physics and/or chemistry, boys with neither course, girls with physics and/or chemistry, girls with neither course. The mean and standard deviation was determined for each group of students on all of the scores.

Mean and standard deviation of student responses to the semantic differential entitled "science" are presented in Table 1a. All of the mean scores of the group that had taken physics and/or chemistry (P/C) were higher than the mean scores of the group that had taken neither course (No P/C). This is true for both boys and girls.

To test the difference between the mean scores of the two groups, the two-tailed z-test[15] was used. The results of this test were tabulated in Table 1b. Students who took physics and/or chemistry viewed science more favorably than those who did not take these courses on the evaluation and activity dimensions. In addition, boys who took at least one of the courses responded more favorably on the potency dimension than boys who did not take either course. Lower scores were given science by both groups of girls on the potency dimension, and by all groups on the personality dimension.

In Table 2a are mean and standard deviation of pupil scores on the semantic differential scale entitled "scientists." Results of the z-test, presented in Table 2b, indicate that students who took physics and/or chemistry did not rate scientists more favorably than students who took neither course.

Data in Table 3 demonstrate that students who took physics and/or chemistry rated science teachers more favorably on the evaluation dimension than students who took neither course. In addition, students with advanced science responded more favorably on the activity and personality dimensions but only one of these differences was large enough to be statistically significant at .05 level using the two-tailed z-test. However, the differences between the two groups tended to affirm the common-sense notion that students who took physics and/or chemistry had more favorable attitudes toward science teachers than students who did not take these courses.

Marked differences between students in the two groups were found on responses to "myself as a scientist" (Table 4). Boys and girls who took physics and/or chemistry rated themselves significantly higher on most dimensions of this scale than students who did not take these courses. Further, it is interesting to note that the mean response for all four groups was highest on the personality dimension (Table 4a). This was most pronounced for girls.

In Tables 5 and 6, z-tests of differences between boys and girls are presented. No significant differences were observed for either group in the mean scores on the scale entitled "science." This was true for both the group who had taken physics and/or chemistry and those who had taken neither course. All of the differences on the scales entitled "scientists" and "science teachers" indicated that girls held more positive attitudes than boys toward scientists and science teachers.

Differences between boys and girls on the scale "myself as a scientist" generally favored boys. One notable exception to this was

the personality dimension for the group which had taken neither physics nor chemistry. Here girls perceived themselves more positively than boys in the same group.

Discussion

It should be noted that all of the statistically significant differences between boys and girls who took physics and/or chemistry and those who took neither course were in favor of the former group. One might conclude, therefore, that these students possessed a more positive general attitude. Results on the scale entitled "scientists" did not support this contention since the two groups essentially demonstrated similar attitudes toward scientists. Consequently, one can infer that students who took physics and/or chemistry had more positive attitudes toward science than those who did not take these courses. In addition, their attitudes toward science teachers were more favorable.

In examining results on the "science," "scientists," and "science teachers" scales, it was found that student responses on the potency and personality dimensions were generally lower than their responses on the evaluation and activity dimensions. Comparison of students who took physics and/or chemistry and those who took neither course on the potency and personality dimensions showed that the differences in means were statistically significant in only one of the twelve cases. Furthermore, different results were observed on the personality dimension of the scale entitled, "myself as a scientist." As indicated in the previous section, mean scores for all groups were higher on the personality dimension of this concept than the mean scores on the other three dimensions. Since students rated the personality dimension for science, scientists, and science teachers relatively lower than the other dimensions, it is possible to infer that students perceived science, scientists, and science teachers as rather detached and unfriendly. Moreover, their response on the scale "myself as a scientist"

suggested that students were saying, "If I were a scientist, I would not be aloof and unfriendly--I'd be a nice, friendly one."

In examining the attitudinal differences between boys and girls, it is interesting to compare the proportion of boys that have taken physics and/or chemistry with the proportion of girls in this group. Of 837 girls in this sample, 385 (46%) have taken either or both of these courses, whereas, 510 boys of 789 in the sample (65%) have taken at least one of these courses (Table 1a).

Much of the difference in attitudes held by boys and by girls can be attributed to cultural influences. Certainly boys took advanced science more frequently than girls. This is compatible with the cultural premise that it is acceptable for boys to be involved in science, but girls should engage in more "feminine" pursuits.[16] Moreover, boys perceived themselves more favorably in the role of a scientist than was the case for girls. Girls, on the other hand, gave more favorable responses than boys to the scale entitled "scientists" and "science teachers." This may, in part, be attributed to the fact that girls in our culture tend to be more affirmative than boys.

To test this hypothesis, data from the semantic differential scale entitled "teachers" were analyzed (Table 7). A z-test of the difference in mean scores for boys and girls showed that girls rated teachers much more favorably (Table 7b). These data support the notion that, in rating groups of people at least, girls tend to give more favorable responses than boys. This also supports the cultural influence hypothesis, since girls in our culture tend to be more "people oriented."

Analysis of attitudes of boys and girls toward science is a complex matter. One problem is that of defining what is meant by science. Attitudes toward the institution are different from those toward the people involved in doing science, and still different from the personalized matter represented by "myself as a scientist."

Conclusions and Implications

1. Students who took physics and/or chemistry demonstrate more favorable attitudes toward science than students who took neither of these courses.

2. No significant differences were found in attitudes toward scientists between students who took physics and/or chemistry and those who took neither course.

3. Students who took physics and/or chemistry demonstrated more favorable attitudes toward science teachers than students who took neither course.

4. When compared to students who took neither course, those who took physics and/or chemistry demonstrated more favorable attitudes on a semantic differential scale entitled "myself as a scientist."

5. On the personality dimension of the scales "science," "scientists," and "science teachers" the mean score for all groups of students was lower than the mean scores on the evaluation and activity dimensions.

6. On the personality dimension of the scale "myself as a scientist," the mean score for all groups of students was higher than the mean score on other dimensions.

7. No significant differences were found between boys and girls on the semantic differential scale entitled "science."

8. Girls demonstrated more favorable attitudes than boys toward scientists.

9. Girls demonstrated more favorable attitudes than boys toward science teachers.

10. Boys demonstrated more favorable attitudes than girls on the semantic differential scale entitled "myself as a scientist."

11. Cultural influence may account for differences in attitudes of boys and girls.

Differences in response to a semantic differential were found between boys and girls, as well as between students who had and those who had not taken physics and/or chemistry. A question needing investigation concerns the degree to which students in the four groups were responding to the same concepts. That is, were students who took physics and/or chemistry and those who did not take these courses responding to the same notion when they marked the semantic differential scale entitled "science"? Did "science" mean the same thing to students in these two groups? Did the word "scientist" have the same meaning for boys and for girls? Lowery's work with elementary school children suggested that science means different things to boys and to girls.[17] Future studies should explore this issue among high school students.

Differences in attitudes which were identified in this study appear to be affected as much by cultural influences as by education. Students' attitudes toward scientists appeared to be unaffected by the amount of science taken. Differences between the sexes followed cultural expectations. Thus, one could conclude that the impact of science instruction on students' attitudes is small.

If instruction in science is to have a greater influence on attitudes, instructional programs must provide experiences whereby students can learn more about the nature of the scientific endeavor. Students also need opportunities to learn about scientists' work and what they are like as people. Unless science educators make a conscious effort to help young people acquire favorable attitudes toward science and scientists, the affective component of students' education in the sciences will continue to be that generated by the mass media and encyclopedic textbooks.

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TABLE 1a

Semantic Differential Scores: Science
(Mean and Standard Deviation)
Students Grouped by Science Courses Taken and by Sex

		N	EVAL.	POT.	ACT.	PER.
P/C	M	510	4.063(1.029)	3.404(1.079)	3.633(1.113)	3.255(0.963)
	F	385	3.988(1.121)	3.312(1.120)	3.620(1.174)	3.240(0.872)
No P/C	M	279	3.693(1.197)	3.217(1.102)	3.410(1.198)	3.223(1.031)
	F	452	3.718(1.231)	3.251(1.166)	3.451(1.244)	3.182(0.952)

TABLE 1b

z-Test of Difference Between Students with
Physics and/or Chemistry and Those with Neither Course

	EVAL.	POT.	ACT.	PER.
M	4.55**	3.40**	2.62**	0.44
F	3.29**	0.77	2.01*	0.91

* for $p < .05$, $z > 1.96$

* for $p < .01$, $z > 2.58$

TABLE 2a

Semantic Differential Scores: <u>Scientists</u>
(Mean and Standard Deviation)
Students Grouped by Science Courses Taken and by Sex

		N	EVAL.	POT.	ACT.	PER.
P/C	M	510	3.979(1.122)	2.966(0.999)	3.914(1.165)	3.148(1.046)
	F	385	4.142(1.051)	3.106(0.982)	4.114(1.106)	3.267(0.981)
No	M	279	3.876(1.185)	3.007(1.039)	3.778(1.022)	3.191(1.022)
P/C	F	452	4.023(1.147)	3.121(1.094)	4.055(1.136)	3.334(1.032)

TABLE 2b

z-Test of Difference Between Students with
Physics and/or Chemistry and Those with Neither Course

	EVAL.	POT.	ACT.	PER.
M	1.21	-0.54	1.64	-0.55
F	1.55	-0.20	0.75	-0.95

*for $p < .05$, $z > 1.96$

TABLE 3a

Semantic Differential Scores: Science Teachers
(Mean and Standard Deviation)
Students Grouped by Science Courses Taken and by Sex

		N	EVAL.	POT.	ACT.	PERS.
P/C	M	510	3.591(1.244)	2.913(0.914)	3.472(1.135)	3.254(1.129)
	F	385	3.920(1.137)	2.996(0.836)	3.819(1.072)	3.589(1.052)
No	M	279	3.380(1.373)	2.868(1.007)	3.289(1.262)	3.126(1.210)
P/C	F	452	3.733(1.219)	2.994(0.965)	3.670(1.190)	3.441(1.141)

TABLE 3b

z-Test of Difference Between Students with
Physics and/or Chemistry and Those with Neither Course

	EVAL.	POT.	ACT.	PER.
M	2.19*	0.63	2.08*	1.48
F	2.28*	0.03	1.89	1.94

*for $p < .05$, $z > 1.96$

TABLE 4a

Semantic Differential Scores: Myself as a Scientist
(Mean and Standard Deviation)
Students Grouped by Science Courses Taken and by Sex

		N	EVAL.	POT.	ACT.	PER.
P/C	M	510	3.246(1.355)	2.948(1.007)	3.514(1.270)	3.566(1.228)
	F	385	2.908(1.307)	2.762(0.949)	3.321(1.306)	3.610(1.159)
No P/C	M	279	2.779(1.316)	2.804(1.065)	3.085(1.305)	3.375(1.240)
	F	452	2.606(1.357)	2.614(1.070)	3.114(1.360)	3.567(1.250)

TABLE 4b

z-Test of Difference Between Students with
Physics and/or Chemistry and Those with Neither Course

	EVAL.	POT.	ACT.	PER.
M	5.16*	1.88	4.49**	2.08*
F	3.26*	2.10*	2.24*	0.51

*for $p < .05$, $z > 1.96$
**for $p < .01$, $z > 2.58$

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TABLE 5

z-Test of Difference Between Boys and Girls
With Physics and/or Chemistry

	EVAL.	POT.	ACT.	PER.
Science	1.03	1.24	0.17	0.24
Scientists	-2.21*	-2.09*	-2.60**	-1.73
Science Teachers	-4.06**	-1.39	-4.64**	-4.53**
Myself as a Scientist	4.09**	2.80**	2.22*	-0.54

* for $p < .05$, $z > 1.96$

** for $p < .01$, $z > 2.58$

TABLE 6

z-Test of Difference Between Boys and Girls
No Physics and/or Chemistry

	EVAL.	POT.	ACT.	PER.
Science	-0.27	-0.39	-0.44	0.55
Scientists	-1.66	-1.39	-3.33**	-1.82
Science Teachers	-3.62**	-1.69	-4.11**	-3.54**
Myself as a Scientist	1.69	2.34**	-0.28	-2.02*

* for $p < .05$, $z > 1.96$

** for $p < .01$, $z > 2.58$

TABLE 7a

Semantic Differential Scores: Teachers
(Mean and Standard Deviation)
Students Grouped by Science Courses Taken and by Sex

		N	EVAL.	POT.	ACT.	PER.
P/C	M	510	3.805(1.079)	3.026(0.718)	3.441(1.040)	3.398(0.991)
	F	385	4.164(0.892)	3.108(0.654)	3.797(1.012)	3.675(0.917)
No	M	279	3.533(1.239)	2.924(0.855)	3.311(1.169)	3.173(1.116)
P/C	F	452	4.100(1.010)	3.138(0.824)	3.793(1.095)	3.558(1.070)

TABLE 7b

z-Test of Difference Between Students with
Physics and/or Chemistry and Those with Neither Course

	EVAL.	POT.	ACT.	PER.
M	3.21**	1.78	1.61	2.91**
F	0.96	-0.57	0.05	1.68

*for $p < .05$, $z > 1.96$

**for $p < .01$, $z > 2.58$

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