A STUDY OF SPATIAL ABILITY AS A PREDICTOR OF SUCCESS IN NEW YORK STATE REGENTS CHEMISTRY

FINAL THESIS

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by

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Abstract

The purpose of this study was to determine which of the following variables contributed most to students' success on the New York State Regents Chemistry examination. The four variables to be assessed are Space Relations, Numerical Ability, Verbal Reasoning and Language Usage. Studies by Carter, LaRussa and Bodner (1987) using college students enrolled in general chemistry suggest there is a significant relationship between spatial ability and chemistry performance.

Based on such research, it is hypothesized that a similar relationship exists at the secondary level. In order to see if such a relationship exists an investigation to determine the validity of this hypothesis was tested using New York State Regents Chemistry final exam scores with the subtest raw scores of Space Relations, Numerical Ability, Verbal Reasoning and Language Usage for sixty students enrolled at West Irondequoit High School during the academic years 1986 through 1988.

The results of this investigation based on simple linear and multiple forward stepwise regression analysis revealed the Numerical Ability and Verbal Reasoning have the greatest influence as predictors of success on chemistry performance. Space Relations and Language Usage showed minimal impact on student achievement.

Since the regression analyses indicate that all of the four independent variables are explaining small amounts of the variation

in the Regents Chemistry exam scores a Chi Square analysis was performed with these variables for the purpose of determining the global effects on Regents chemistry exam scores. The Chi Square analysis at the ninety five percent confidence level revealed that Numerical Ability and Language Usage impacted the most on students' chemistry performance.

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Chapter I

Introduction

Present studies point to spatial ability as a predictor of success in general college chemistry. Research conducted by Carter, LaRussa and Bodner at Purdue University measured two areas in the spatial domain using multiple choice tests as the instruments of measurement. The first area, spatial orientation, measured a "student's ability to remain unconfused by changing orientations of visual stimuli." The second area, spatial visualization, measured a student's "mental manipulation of pictorially presented stimuli" (Bodner and MacMillen 1987). Additionally, it was found that these spatial ability tests served to measure, similarly, the student's ability to disembed and restructure information contained within chemistry exam problems. The link between these abilities measured, to student performance on chemistry exams, showed that a significant relationship existed (Bodner and McMillen 1986). The evidence suggested that student success, in solving chemistry problems, is related to his/her ability to disembed and reorganize (restructure) relevant material given in a problem.

Based on such research, it is hypothesized that a similar relationship exists at the secondary level. The validity of this hypothesis was tested using New York Regents Chemistry final exam scores with the subtest scores of Space Relations obtained from

Differential Aptitude Tests. Three additional measures of Numerical Ability, Language Usage and Verbal Reasoning were added to see if these variables lend contributory support as far as predicting student success in Regents chemistry.

Since spatial abilities is of primary interest here, the spatial relation subtest scores used in this study measure "ability to visualize a constructed object from a picture of a pattern" and the "ability to imagine how an object would appear if rotated in various ways" (Bennett, Seashore, Weismann 1967). Descriptions of what the subtests of Numerical Ability, Language Usage and Verbal Reasoning measure are given in the Methods section.

A previous study predicting chemistry achievement using Differential Aptitude Test subtests scores was conducted with a group of eleventh grade girls (Bae 1967). The results pointed to the subtests of Verbal Reasoning and Numerical Ability as being the best predictors for chemistry achievement. Furthermore, Layton and Swanson's (1958) correlations using Differential Aptitude Test subtest scores of ninth grade students as far as predicting eleventh grade test scores and high school rank point to Verbal Reasoning as the single best predictor.

The expectations, considering studies found in the literature, would seem to indicate that Spatial Relations account for a statistically significant portion of the variance in chemistry exam scores but that other variables may be operating insofar as

influencing chemistry performance. Certainly the manipulative processes employed by successful students in the management of a problem bear some conjunction with the spatial abilities already present in the students' repertoire. But the degree of explanatory power of one variable, namely Space Relations, would seem to warrant additional measures in terms of explaining more of the variance in the New York State Regents chemistry exam.

Chapter II

Methods

Tests of Spatial Relations, Numerical Ability, Verbal Reasoning and Language Usage

Four measures were used in this study to determine if the same correlation between spatial ability and performance in chemistry exists at the secondary level and if the other variables noted are more significant. The tests administered consisted of a sixty item space relations subtest, a fifty item verbal reasoning subtest, a forty item numerical ability subtest and a sixty item language usage subtest. The time allotted for each subtest was as follows:

Test	Time Allotment
Verbal Reasoning	Thirty minutes
Numerical Ability	Thirty minutes
Space Relations	Twenty five minutes
Language Usage	Twenty five minutes

Descriptions of Additional Individual Subtests Used

The Verbal Reasoning test measures ability to understand concepts framed in words aimed at a student's ability to abstract or generalize. The Numerical Ability Test is a measure of the student's ability to reason with numbers, to manipulate numerical relationships, and to deal intelligently with quantitative materials. The Language Usage test measures the student's ability

to detect errors in grammar, punctuation and capitalization which is highly predictive of success in a variety of courses (Bennett, Seashore, Wesman).

Subjects

The subjects included 60 randomly chosen sophomore and junior students enrolled in a two semester New York State Regents Chemistry course at West Irondequoit High School in Irondequoit New York. Three sections of twenty students were selected from the academic years 1986, 1987, and 1988. The course was taught by the same instructor and used the same text and covered the same content. Regents chemistry lectures met Monday through Friday for forty two minute periods. All sections were taught in a classroom of approximately twenty seven students also meeting for an additional forty two minute period of twenty five to twenty eight for weekly laboratory experiments. The Differential Aptitude Test was administered during the first semester of the student's freshman year.

Chemistry Performance

Chemistry achievement was measured by a three hour final exam written by the New York State Board of Regents. All exams had the same format consisting of fifty six multiple choice questions on part I and twelve topical sections (as outlined on the New York State Regents Chemistry Syllabus) of five multiple choice questions each of which the student must choose seven of the twelve topical sections comprising a total of thirty five questions on the part II.

A total of ninety one questions were scored. The exams were assumed to be a valid measure of chemistry performance. The scoring and the categorical nature of these tests is described in Appendix A.

Chapter III

Statistical Analysis

The statistical analysis is divided into two phases, Phase I and Phase II which are described below.

Phase I will look at the amount of variation in the Regents Chemistry scores explained by each of the independent variables when taken separately. In the previous chapter a host of factors that could influence performance on the Regents Chemistry exam were discussed. From this vast array of possible influences which could explain the observed variation in the Regents Chemistry exam scores found in the sample, four factors were chosen to serve as independent variables for the statistical analysis. In Phase I each of these independent variables (Verbal Reasoning, Language Usage, Space Relations and Numerical Ability) will be analyzed separately in order to ascertain their relative explanatory power. Consequently Phase I will have four subsections and the statistical procedure in each will be a simple linear regression.

In Phase II the statistical analysis turns to the task of building the best explanatory model when two or more of the above independent variables are combined in a prediction equation. The statistical procedure here will be stepwise multiple regression. The final section will contain conclusions concerning statistical analysis.

Data Listing

	NYS	VR	NA	SR	LU
1	74	19	20	24	9
2	55	21	19	15	35
3	69	39	38	52	34
4	96	39	38	45	39
5	75	31	37	30	37
6	68	42	31	53	33
7	93	49	37	52	49
8	79	21	33	48	40
9	63	37	24	45	36
10	65	29	24	31	31
11	75	38	31	37	41
12	79	24	33	37	37
13	59	21	25	20	26
14	70	26	23	25	26
15	84	33	29	29	42
16	85	30	27	27	34
17	69	24	25	14	22
18	77	36	32	44	37
19	73	28	28	42	29
20	81	32	37	52	23
21	80	40	31	35	29
22	54	28	32	27	25
23	50	23	22	31	32
24	70	28	25	38	32
25	77	37	27	38	33
26	71	21	28	20	34
27	76	34	34	36	35
28	79	26	32	35	37
29	83	39	38	52	42
30	70	24	30	38	27
31	62	29	16	25	30
32	62	34	26	26	28
33	76	29	17	13	40
34	77	28	32	37	30
35	73	39	40	49	40
36	66	13	30	37	27
37	79	18	33	34	25
38	80	32	32	18	38
39	74	18	32	25	18
40	63	31	21	28	23
41	73	29	34	51	38
42	71	29	30	50	19
43	79	25	25	22	29

	NYS	VR	NA	SR	LU
44	66	14	29	27	29
45	66	44	31	47	43
46	86	36	31	42	36
47	75	41	18	46	40
48	81	39	34	36	32
49	72	24	31	15	35
50	64	32	27	33	39
51	74	39	24	44	47
52	58	16	28	21	27
53	62	23	16	17	22
54	87	40	37	40	37
55	77	19	29	30	20
56	68	35	33	39	29
57	74	36	28	43	35
58	67	18	29	35	35
59	55	34	30	31	30
60	54	26	23	28	24

Phase I

1. Numerical Ability with New York State Regents Chemistry

In this group, the linear regression reveals that scores on the Numerical Ability subtest have an actual range of twenty four points (24 to 46) out of a possible range of forty. The distribution of Numerical Ability raw scores was -0.3942 (negatively skewed) and well within the limits of normality. The mean Numerical Ability raw score was 28.9 which was 1.1 points below the median (30). The standard deviation was 5.78. In comparison, the New York State Regents exam had a range of forty six points (50 to 96) out of a possible range of one hundred. The mean score was about seventy two points which was one point below the median (73). The standard deviation was 9.60. The distribution was -0.0788 (negatively skewed) and was within normal limits.

The data shows that for an increase of one point on the Numerical Ability subtest score, the New York State Regents exam score will increase by 0.84 points. More appropriately, for every increase of five points on the Numerical Ability subtest the New York State Regents exam score will increase by four points. Coupled with the fact that twenty six percent of the variation in the chemistry exam scores is explained by the Numerical Ability scores suggests a minimal influence on Regents chemistry achievement.

Furthermore, for one hundred individuals all obtaining a mean score of 29 on the Numerical Ability subtest, we would predict

the average New York State Regents chemistry score to be about seventy two. Close to that average we would expect to find an eight point spread around the residuals. This spread appears to be within acceptable limits considering the value of r^2 (0.26). In fact the t-value at the ninety five percent confidence level (+2.00) indicates that ninety five out of one hundred students will have Regents Chemistry exam scores between seventy and seventy four. This gives a prediction interval of about four points.

Summary Statistics for NA with NYS

$n = 60$	$a = 47.59246$
$\bar{x} = 28.93333$	$b = 0.84358$
$s_x = 5.78387$	$r = 0.5085$
$\tilde{x} = 30$	$r^2 = 0.25857$
$sk_x = -0.39412$	$s_{y.x} = 8.33$
$y = 71.99999$	$y_{c(\text{for } x = 29)} = 72.06$
$s_y = 9.5952$	$s_{yc} = 1.08$
$y = 73$	allowance = 2.15
$sk_y = -.07883$	Max. = 74.15
Summation of x = 1736	Min. = 69.85
Summation of y = 4319.999	Prediction = 4.3
Summation of $x^2 = 52202$	Interval(x=29)
Summation of $y^2 = 3164$	

2. Verbal Reasoning with New York State Regents Chemistry

For this same group, scores on the Verbal Reasoning subtest have an actual range of thirty six points (13 to 49) out of a possible range of fifty points. The distribution of Verbal Reasoning raw scores was -0.03191 (negatively skewed) and was well within the limits of normality. The mean Verbal Reasoning raw score was 29.8 which was 0.8 points above the median (29). The standard deviation was 8.18.

The data shows that for an increase of one point on the Verbal Reasoning subtest score, the New York State Regents exam score will increase by 0.44 points. But more appropriately, for every five point increase on the Verbal Reasoning subtest, the New York State Regents chemistry score will increase by two points. Coupled with the fact that fourteen percent of the variation in the Regents Chemistry exam scores is explained by the Verbal Reasoning subtest scores, lends minimal support insofar as having a major influence on Regents chemistry achievement.

Furthermore, for one hundred individuals all obtaining a mean score of 29 on the Verbal Reasoning subtest, we would predict the average New York State Regents chemistry score to be just about seventy two. Close to that average we would expect to find a nine point spread around the residuals which is within acceptable limits considering the value of r^2 (0.14). In fact the t-value at the ninety five percent confidence level (+2.00) indicates that ninety

five out of one hundred subjects will have Regents Chemistry exam scores between sixty nine and seventy four. This gives a prediction interval of about five points.

Summary Statistics for VR with NYS

$n = 60$	$a = 58.86309$
$\bar{x} = 29.81667$	$b = 0.44059$
$s_x = 8.17912$	$r = 0.37557$
$\tilde{x} = 29$	$r^2 = 0.14105$
$sk_x = -0.03191$	$s_{y.x} = 8.96912$
$y = 71.99999$	$y_{c(\text{for } x = 29)} = 71.64$
$s_y = 9.5952$	$s_{yc} = 1.16$
$y = 73.00$	allowance = 2.32
Summation of $x = 1789$	Max. = 74.00
Summation of $y = 4319.999$	Min. = 69.00
Summation of $x^2 = 57289.02$	Prediction = 5.0
Summation of $y^2 = 316471.9$	Interval(for x = 29)

3. Space Relations with New York State Regents Chemistry

In this group, scores on the Space Relations subtest have an actual range of forty points (13 to 53) out of a possible range of sixty. The distribution of Space Relations scores was -0.0793 (negatively skewed) and well within the limits of normality. The mean Space Relations raw score was thirty four which was one point below the median (35). The standard deviation was 11.09.

The data shows that for a one point increase on the Space Relations subtest score, the New York State Regents Chemistry exam score will increase by 0.31 points. More appropriately, for every increase of seven points on the Space Relations subtest score, the New York State Regents Chemistry exam score will increase by two points. Coupled with the fact that thirteen percent of the variation in the Regents chemistry exam scores is explained by the Space Relations score suggests almost a negligible influence on Regents chemistry performance.

Furthermore, for one hundred individuals obtaining a mean score of thirty four on the Space Relations subtest, we would predict the average New York State Regents chemistry exam score to be about seventy two. Close to that average we would expect to find a nine point spread around the residuals. This spread appears to be within acceptable limits considering the value of r^2 (0.13). The t-value at the ninety five percent confidence level (+2.00) indicates that ninety five out of one hundred students will have Regents chemistry scores between seventy one and seventy three. This gives a prediction interval of about two and one half points.

Summary Statistics for SR with NYS

$n = 60$	$a = 61.26866$
$\bar{x} = 34.35$	$b = 0.31241$
$s_x = 11.09256$	$r = 0.36116$
$\tilde{x} = 35$	$r^2 = 0.13044$

$sk_x = -0.07973$

$y = 71.99999$

$s_y = 9.5952$

$y = 73.00$

$sk_y = -0.07883$

Summation of $x = 2061$

Summation of $y = 4319.99$

Summation of $x^2 = 78054.98$

Summation of $y^2 = 316471.9$

$s_{y.x} = 9.02434$

$y_{c(\text{for } x = 34)} = 71.89$

$s_{yc} = 1.17$

allowance = 1.36

Max. = 73.37

Min. = 70.74

Prediction

Interval(for x=34) = 2.62

4. Language Usage with New York State Regents Chemistry

In this group, scores on the Language Usage subtest have an actual range of forty (9 to 49) out of a possible range of sixty. The distribution was -0.40903 (negatively skewed) and well within the limits of normality. The mean Language Usage raw score was thirty two which was one point below the median (33). The standard deviation was 7.52.

The data shows that for an increase of one point on the Language Usage subtest score, the New York State Regents Chemistry exam score will increase by 0.42 points. But more appropriately, for every increase of five points on the Language Usage subtest score, the New York State Regents Chemistry exam score will increase by two points. Considering that only thirteen percent of the variation in the chemistry exam scores is explained by the Language Usage scores suggests that minimal credibility is associated with

Language Usage as a predictive influence on Regents chemistry achievement.

In addition, for one hundred individuals obtaining a mean score of thirty two on the Language Usage subtest, we would predict the average New York State Regents exam score to be about seventy two. Close to that average we would expect to find a nine point spread around the residuals which is within acceptable limits considering the value of r^2 (0.13). The t-value at the ninety five percent confidence level (+2.00) indicates that ninety five out of one hundred students will have Regents chemistry exam scores between seventy one and seventy three. This gives a prediction interval of about two and one half points.

Summary Statistics for LU with NYS

$n = 60$	$a = 57.12755$
$\bar{x} = 32.18333$	$b = 0.46212$
$s_x = 7.52283$	$r = 0.36231$
$\tilde{x} = 33$	$r^2 = 0.13127$
$sk_x = -0.40903$	$s_{y.x} = 9.02005$
$y = 71.99999$	$y_{c(\text{for } x=32)} = 71.9$
$s_y = 9.5952$	$s_{yc} = 1.17$
$y = 73$	allowance = 1.36
$sk_y = 0.07883$	Max. = 73.36
Summation of x = 1931	Min. = 70.74
Summation of y = 4319.99	Prediction = 2.62
Summation of x^2 = 65485	Interval(for x=32)
Summation of y^2 = 316471	

Looking at these four independent variables separately it should be noted that each variable is explaining small amounts of the variation in the dependent variable, New York State Regents Chemistry. In order to determine if more of the variation in the Regents chemistry exam scores is explainable, we will turn to the task of combining two or more of the independent variables through the use of multiple regression analysis.

Phase II

Of the four independent variables, the variable, Numerical Ability, showed the strongest explanatory power. But even this variable explained only twenty six percent of the variation in the chemistry scores ($r^2 = 0.26$). Verbal Reasoning showed the second best relationship with chemistry scores but it accounted for only fourteen percent of the variation in the chemistry scores. Language Usage and Space Relations accounted for only thirteen percent of the variation in the chemistry scores. This lack of explanatory power on the part of the independent variables is not completely surprising since the Regents chemistry exam is designed to measure a variety of skills relating to performance in chemistry.

Table 1 below shows the correlation matrix between the dependent variable and the four independent variables. Inspection of this table indicates that all the variables show significant inter-correlations with each other. The reader should note that the statistics reported are Pearson Product Moment Correlations while

the explanatory power discussed above is simply the square of these correlation coefficients. Column 1 gives the correlation coefficients for each of the independent variables with the dependent variable New York State Regents Chemistry.

Table 1

Correlation Matrix

	1 NYS	2 VR	3 NA	4 SR	5 LU
NYS	1	.37557	.5085	.36116	.36231
VR	.37557	1	.31395	.57966	.57654
NA	.5085	.31395	1	.5599	.29244
SR	.36116	.57966	.5599	1	.38066
LU	.36231	.57654	.29244	.38066	1

Table 2 provides the descriptive statistics for all five variables. The reader should note that the standard errors for the means are all small values (less than 1.5 points). The standard deviations range from about six points to eleven points. The distributions for the Regents chemistry scores, the Verbal Reasoning scores and the Space Relations scores are nearly perfect normal distributions. Numerical Ability and Language Usage show a moderate negative skewness. Looking at the range from minimum to maximum, all five variables indicate that the measuring instruments have a high discrimination index.

Table 2

Means and Standard Deviations

Var. Name	Size	Mean	Sample Std. Dev.	Sample Std. Err.
NYS	60	71.9999	9.5952	1.23873
VR	60	29.81667	8.17912	1.05592
NA	60	28.93333	5.78387	.74669
SR	60	34.35	11.09256	1.43204
LU	60	32.18333	7.52283	.97119

While the relatively high degree of intercorrelations apparent in Table 1 are not encouraging for the prospects of dramatic improvement in the explanatory power through the use of a multiple prediction equation, Phase II will look at whatever degree of improvement in the explanatory power is possible.

Since Numerical Ability showed the highest individual relationship with the chemistry scores it was expected to be the first variable selected by the stepwise multiple regression procedure and in fact was so selected. The reader should note the correspondence between the statistics given in Table 3 and the previous discussion of Numerical Ability as an independent variable in Phase I.

The stepwise multiple regression procedure selected Verbal Reasoning as the second variable to enter the multiple prediction equation model. Surprisingly it did improve the explanatory power. The adjusted R-square increased from twenty five percent to twenty

Table 3

New York State Regents Chemistry with Numerical Ability

Forward Stepwise Regression

Current Regression Summary Table

Dependent Variable: NYS

Multiple R = .5085
Std Err Est = 8.333
F = 20.2273

Ind Var	B Coef	Std Err(B)	F-Value	Prob
NA	.843579	.187567	20.22733	.0001
Constant				
47.59245				

New York State Regents Chemistry with Numerical Ability

Multiple Correlation Summary

	Multiple R	R-Square
Unadjusted	.5085	.2586
Adjusted	.4958	.2458

Std Error of estimate = 8.333
Sample size = 60

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nine percent, recorded on Table 4, and this improvement actually occurred with a very slight reduction in the standard error of the estimate from 8.33 to 8.11.

Table 4

New York State Regents Chemistry with
Numerical Ability and Verbal Reasoning

Current Regression Summary Table

Dependent Variable: NYS

Multiple R = .557
Std Err Est = 8.1073
F = 12.8218

Ind Var	B Coef	Std Err(B)	F-Value	Prob
VR	.281004	.135917	4.274403	.0432
NA	.718823	.192204	13.98676	.0004

Constant
42.82344

Multiple Correlation Summary

	Multiple R	R-Square
Unadjusted	.557	.3103
Adjusted	.5349	.2861

Std Error of estimate = 8.1073
Sample size = 60

An inspection of Table 5 reveals a miniscule improvement in the explanatory power obtained by the addition of the independent variable Language Usage with the adjusted R-square increasing only from 0.286 to 0.289 and the standard error of the estimate only

Table 5

New York State Regents Chemistry with Numerical Ability, Verbal Reasoning and Language Usage

Current Regression Summary Table

Dependent Variable: NYS

Multiple R = .5699
Std Err Est = 8.0927
F = 8.9807

Ind Var	B Coef	Std Err(B)	F-Value	Prob
VR	.186937	.160454	1.357351	.2489
NA	.688243	.193869	12.60281	.0008
LU	.190192	.173203	1.205798	.2769
Constant 40.39196				

Multiple Correlation Summary

	Multiple R	R-Square
Unadjusted	.5699	.3248
Adjusted	.5373	.2887

Std Error of estimate = 8.0927
Sample size = 60

showing a miniscule reduction from 8.11 to 8.09. This means that the optimal prediction equation model was reached in Table 4 with only two independent variables, Numerical Ability and Verbal Reasoning included.

Since Space Relations was of paramount interest in this investigation the next step in the multiple regression procedure

was taken in order to bring Space Relations into the equation. Table 6 shows an adjusted R-Square of 0.277 which is actually less than the explanatory power obtained in Table 4 at the second step. In fact, there is actually a small increase in the standard error of the estimate thus giving further evidence that the step two description given in Table 4 is the optimum explanatory prediction model. Therefore the optimum multiple regression equation for predicting chemistry scores generated by this sample of students is:

Predicted Chemistry Score = 48.82 + 0.7188 (Numerical Ability Score) + 0.281 (Verbal Reasoning Score)

The next four tables show the scatter plots for each of the independent variables. Inspection of these tables indicates that although the predictive relationships are not strong there may be some important global effects. For example, all of the persons whose scores were above thirty eight in Numerical Ability had scores above seventy on the Regents Chemistry Exam. Chi-Square analyses of statistical independence are therefore warranted in order to determine how strong the global effects actually are.

Interestingly, while none of the independent variables were impressive as specific predictors of Regents Chemistry performance both Numerical Ability and Language Usage show statistically significant and important global effects. Again, Numerical Ability showed the strongest relationship with Regents Chemistry

Table 6

New York State Regents Chemistry with Numerical Ability, Verbal Reasoning, Language Usage and Space Relations

Current Regression Summary Table

Dependent Variable: NYS

Multiple R = .5706
Std Err Est = 8.161
F = 6.6397

Ind Var	B Coef	Std Err(B)	F-Value	Prob
VR	.207998	.181351	1.315459	.2564
NA	.716102	.22351	10.26492	.0023
SR	-.034644	.13471	.06614	.798
LU	.190173	.174666	1.185443	.281

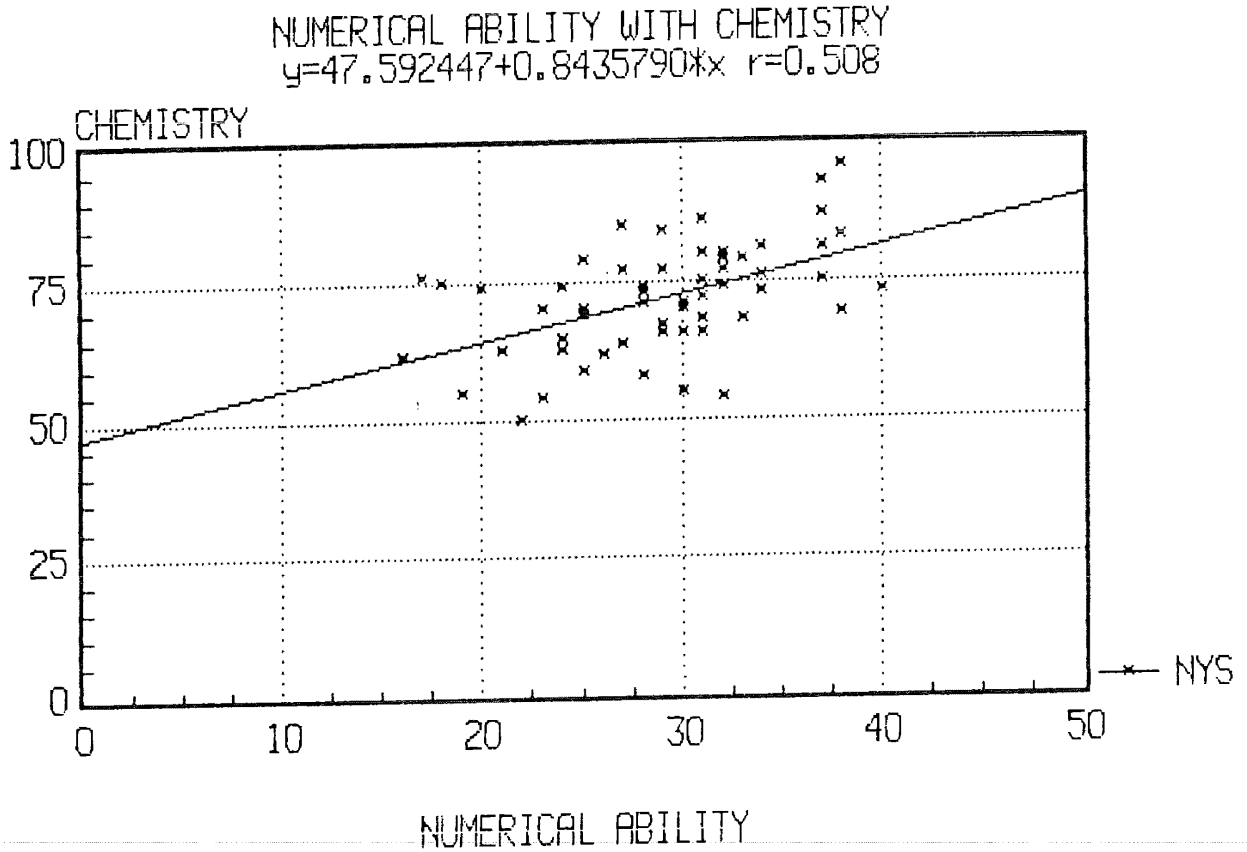
Constant
40.14862

Multiple Correlation Summary

	Multiple R	R-Square
Unadjusted	.5706	.3256
Adjusted	.5259	.2766

Std Error of estimate = 8.161
Sample size = 60

Table 7


NUMERICAL ABILITY WITH CHEMISTRY
y=47.592447+0.8435790*x r=0.508
CHEMISTRY
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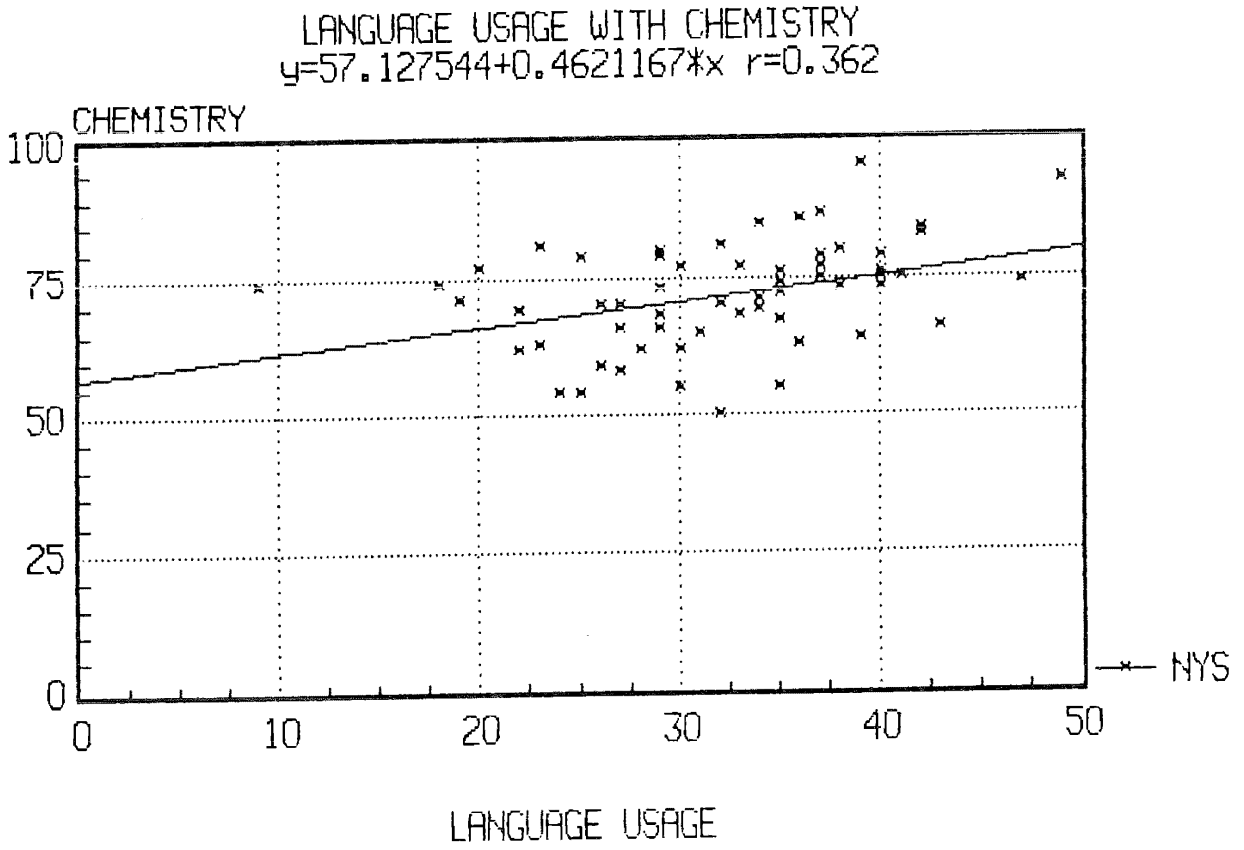
75
50
25
0
0
10
20
30
40
50
NYS
NUMERICAL ABILITY

Table 8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CHEMISTRY
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75
50
25
0
0
10
20
30
40
50
NYS
LANGUAGE USAGE

Table 9

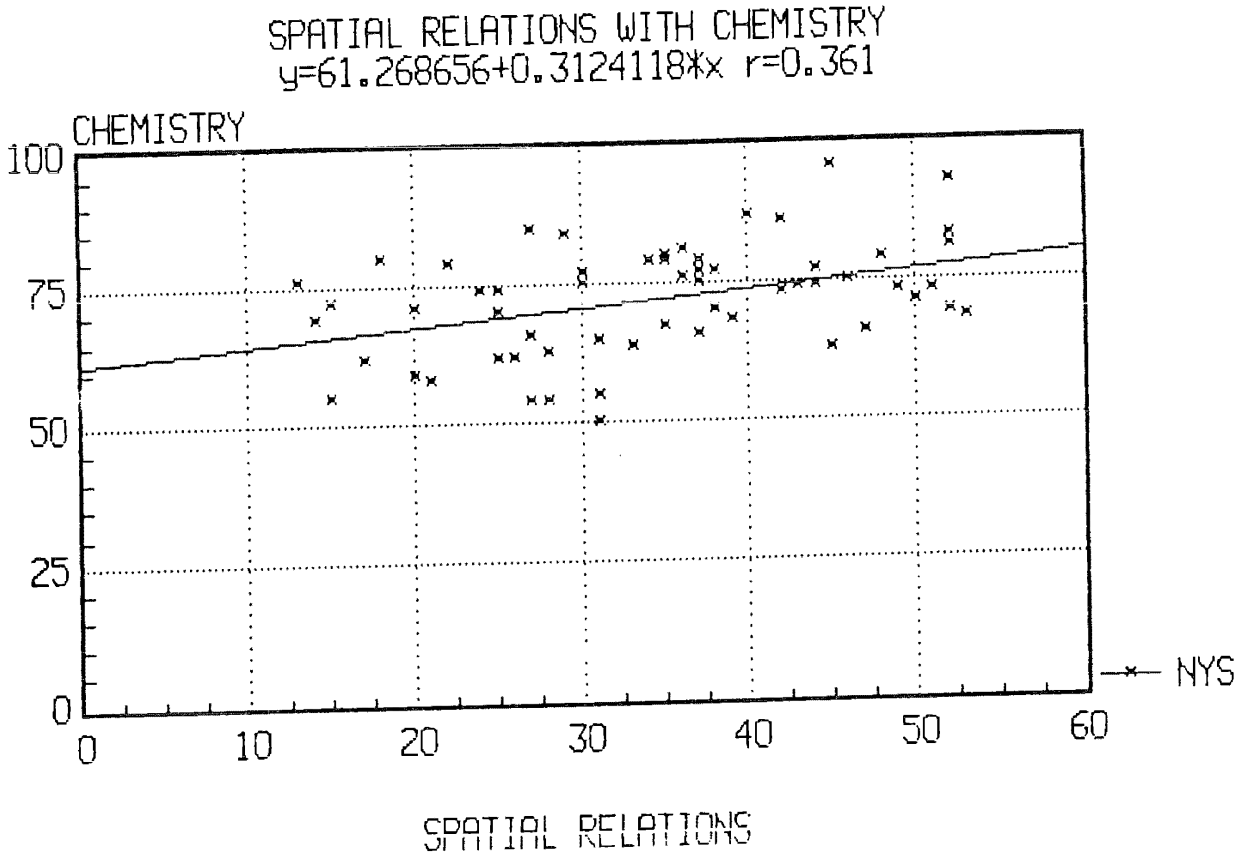
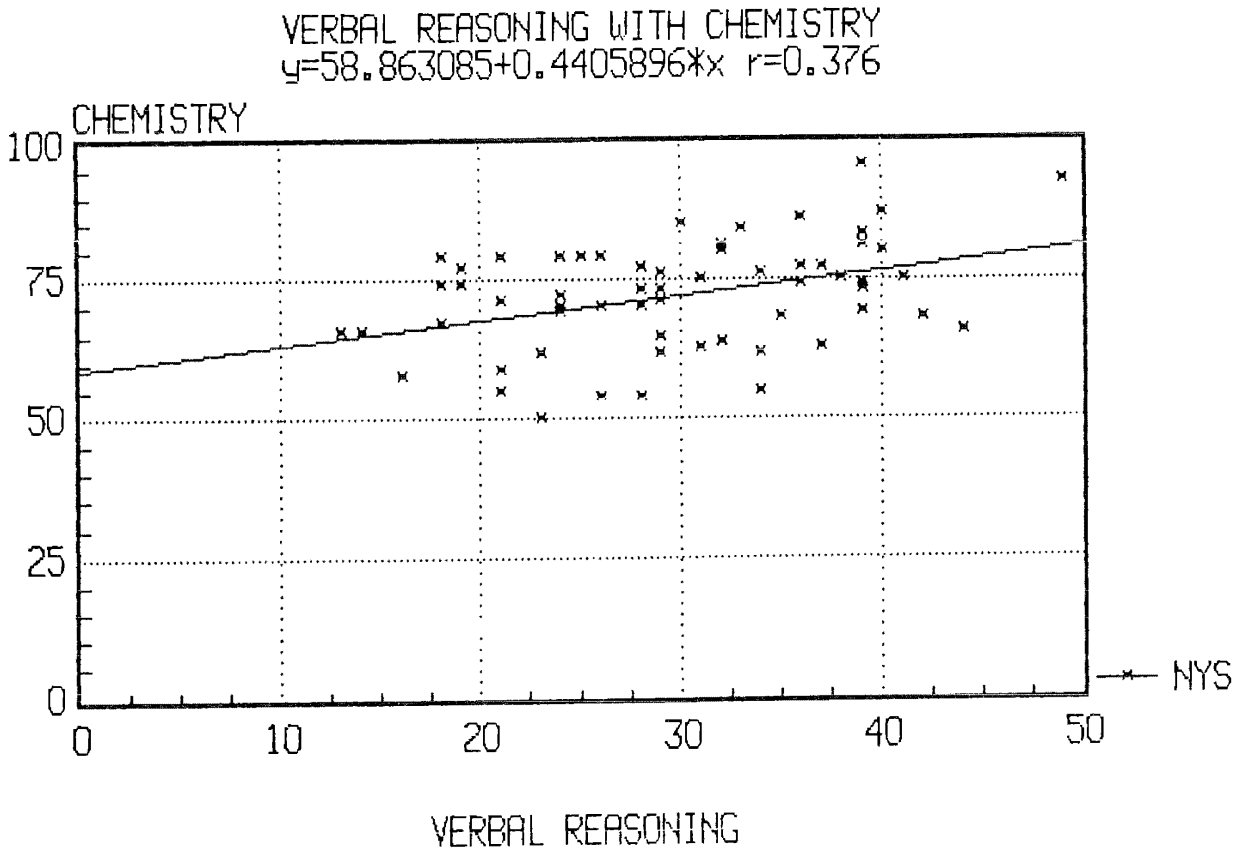

SPATIAL RELATIONS WITH CHEMISTRY
y=61.268656+0.3124118*x r=0.361
CHEMISTRY
100
75
50
25
0
0
10
20
30
40
50
60
NYS
SPATIAL RELATIONS

Table 10


VERBAL REASONING WITH CHEMISTRY
y=58.863085+0.4405896*x r=0.376
CHEMISTRY
100
75
50
25
0
0
10
20
30
40
50
NYS
VERBAL REASONING

with a Cramer's V indicating that thirty two percent of the variation in the chemistry performance categories could be explained by knowing which Numerical Ability category the student was in. This could be interpreted in the sense that a counselor armed with the findings of this study would make categorical predictions of chemistry performance three times more accurately than a counselor that did not have this information.

About the same could be said for a counselor who knew the Language Usage performance category for a student. Since neither the Space Relations analysis nor the Verbal Reasoning analysis showed significant relationships at the ninety five percent confidence level their Cramer's V coefficients cannot be interpreted. In fact, Space Relations was significant at the ninety percent confidence level but Verbal Reasoning was not even significant at the eighty percent confidence level.

Table 11

New York State Regents Chemistry with Numerical Ability
Columns: 1=Low 2=Average 3=High NYS Regents Chemistry
Rows: 1=Low 2=Average 3=High Numerical Ability

Contingency Table - NYS X NA

Cols: NYS C1 Base= 50, Width= 16
Rows: NA R1 Base= 16, Width= 8

	C1	1	2	3	3	TOT
R1	0	0	0	0	0	0
	0	0	0	0	0	0
1	0	6	4	0	0	10
	0	2.3	6.5	1.2	0	10
2	0	7	19	3	0	29
	0	6.8	18.9	3.4	0	29
3	0	1	15	4	0	20
	0	4.7	13	2.3	0	20
3	0	0	1	0	0	1
	0	.2	.7	.1	0	1
TOT	0	14	39	7	0	60
	0	14	39	7	0	60

Summary Statistics

D.F. = 4

Chi-Square = 12.32

Prob = .015

Cramer's V = .32

Contingency Coef = .413

Table 12

New York Regents Chemistry with Verbal Reasoning
Columns: 1=Low 2=Average 3=High NYS Regents Chemistry Ability
Rows: 1=Low 2=Average 3=High Verbal Reasoning

Contingency Table - NYS X VR

Cols: NYS C1 Base= 50, Width= 16
Rows: VR R1 Base=13, Width= 12

	C1	1	2	3	3	TOT
R1	0	0	0	0	0	0
	0	0	0	0	0	0
1	0	5	13	0	0	18
	0	4.2	11.7	2.1	0	18
2	0	8	16	3	0	27
	0	6.3	17.6	3.2	0	27
3	0	1	10	3	0	14
	0	3.3	9.1	1.6	0	14
3	0	0	0	1	0	1
	0	.2	.7	.1	0	1
TOT	0	14	39	7	0	60
	0	14	39	7	0	60

Summary Statistics

D.F. = 4

Chi-Square = 5.8

Prob = .214

Cramer's V = .22

Contingency Coef = .297

Table 13

New York State Regents Chemistry with Language Usage
Columns: 1=Low 2=Average 3=High NYS Chemistry
Rows: 1=Low 2=Average 3=High Language Usage

Contingency Table - NYS X LU

Cols: NYS C1 Base= 50, Width= 16
Rows: LU R1 Base= 9, Width = 14

	C1	1	2	3	3	TOT
R1	0	0	0	0	0	0
	0	0	0	0	0	0
1	0	1	5	0	0	6
	0	1.4	3.9	.7	0	6
2	0	12	21	2	0	35
	0	8.2	22.8	4.1	0	35
3	0	1	13	5	0	19
	0	4.4	12.4	2.2	0	19
3	0	0	0	0	0	0
	0	0	0	0	0	0
TOT	0	14	39	7	0	60
	0	14	39	7	0	60

Summary Statistics

D.F. = 4

Chi-Square = 10.31

Prob = .36

Cramer's V = .293

Contingency Coef = .383

Table 14

New York State Regents Chemistry With Space Relations
Columns: 1=Low 2=Average 3=High NYS Regents Chemistry
Rows: 1=Low 2=Average 3=High Space Relations

Contingency Table - NYS X SR

Cols: NYS C1 Base= 50, Width= 16
Rows: SR R1 Base= 13, Width= 14

	C1	1	2	3	3	TOT
R1	0	0	0	0	0	0
	0	0	0	0	0	0
1	0	6	9	0	0	15
	0	3.5	9.8	1.8	0	15
2	0	7	17	3	0	27
	0	6.3	17.6	3.2	0	27
3	0	1	13	4	0	18
	0	4.2	11.7	2.1	0	18
3	0	0	0	0	0	0
	0	0	0	0	0	0
TOT	0	14	39	7	0	60
	0	14	39	7	0	60

Summary Statistics

D.F. = 4

Chi-Square = 8

Prob = .092

Cramer's V = .258

Contingency Coef = .343

Chapter IV

Conclusions and Recommendations

If the objects and content of the Regents Chemistry Exam do not change then clearly the best schools can do to improve performance on the Regents Chemistry Exam would be to emphasize development of Numerical Ability skills and Language Usage skills and de-emphasize instructional emphasis on the development of Space Relation skills. On the other hand, considering what students may run into in college chemistry, namely, an emphasis on Space Relations skills this researcher recommends modification of the Regents Chemistry Exam in order to more appropriately reward Space Relation skills.

Nonstatistical Conclusions

Given the present disposition of this study, increased attention should be given to enhancing a student's Numerical Ability and Language Usage skills to ensure reasonable success on the chemistry exam. It is fair to say that the results of this study should not be viewed as unequivocally conclusive evidence as far as dictating pedagogy but should nevertheless be considered along with sundry methods for improving student performance.

Another concern up for consideration is the student's present level of cognitive abilities, which cannot be ignored when instructional strategies are being developed. Certainly, efforts should be made to ensure that instructors are sensitive to the differences in cognitive development among students.

Discrepancies between the original hypothesis of Spatial Ability as a significant predictor and the fact that Numerical Ability and Language Usage function in this respect to a much greater extent (as the Chi Square results indicate) may be directly attributable not only to the nature of the test but to the relative degree of cognitive development between secondary level and college level students. According to Levine and Linn (1977) in analyzing and evaluating Piaget's work the "type of scientific reasoning ability used to apply general principles of problem solving to any problem does not usually occur and in fact is only reached by a segment of normal adolescents" (p. 377).

Given the influence of these intervening factors, along with the previous educational experience of high school Sophomores and Juniors (as to those of college students), practical considerations must be assumed when doing studies of this nature.

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Appendices

Appendix A

New York State Chemistry Syllabus Scope and Content

SYLLABUS SCOPE AND CONTENT

The material in this syllabus is organized under three headings: Topics, Understandings and Fundamental Concepts, and Supplementary Information. Materials presented under all the headings will be included in the Regents examination. All the material organized under the headings, Activities, Minimum Requirements, and Supplementary Information in Unit 12*, Laboratory Activities, will also be subject to the Regents examination.

Units 1-9 are required of all students. In addition, a minimum of two Units from Units 5*, 6*, 8*, 9*, 10*, 11*, and 12* are required of all students.

Appendix B

Topical Outline

TOPICAL OUTLINE

Units 1-9 are required of all students. A minimum of two units with an asterisk (*) are required of all students. Numbers in parenthesis refer to page location.

TOPICAL OUTLINE

UNIT 9* - ADDITIONAL MATERIALS IN ORGANIC CHEMISTRY (68)

Teachers who elect this Unit 9* may wish to teach these outlined materials in the appropriate places in Unit 9.

UNIT 10* - APPLICATIONS OF CHEMICAL PRINCIPLES (72)

Teachers who elect this unit 10* may wish to teach materials outlined here in the appropriate places in the syllabus.

UNIT 11* - NUCLEAR CHEMISTRY (77)

Teachers who elect this Unit 11* may wish to teach these outlined materials in the appropriate places in Unit 2.

I. Artificial Radioactivity (77)

A. Artificial transmutation (77)
1. Accelerators

II. Nuclear Energy (77)

A. Fission reaction (77)
1. Fuels
2. Moderators
3. Control rods
4. Coolants
5. Shielding

B. Fusion reaction (78)
1. Fuels
2. High energy requirement

C. Radioactive wastes (79)

D. Uses of radioisotopes (79)
1. Based on chemical reactivity
2. Based on radioactivity
3. Based on half-life

UNIT 12* - LABORATORY ACTIVITIES (81)

This unit is not intended to include all of the Regents Chemistry laboratory requirements. See introduction to Syllabus, p. iv.

I. Measurement (81)

II. Laboratory Skills (82)

III. Laboratory Activities (83)

IV. Laboratory Reports (84)

Appendix C

Scoring on Part I and Part II of the Chemistry Examination

FOR TEACHER USE ONLY

Credits

Part I ....
(Use table below)

Part II ....

Total ....

Rater's Initials .....

Part I Credits

Directions to Teacher.

In the table below, draw a circle around the number of right answers and the adjacent number of credits. Then write the number of credits (not the number right) in the space provided above.

No. Right	Credits	No. Right	Credits
56	65	28	41
55	64	27	40
54	63	26	39
53	62	25	39
52	62	24	38
51	61	23	37
50	60	22	36
49	59	21	35
48	58	20	34
47	57	19	33
46	56	18	33
45	56	17	32
44	55	16	31
43	54	15	30
42	53	14	29
41	52	13	27
40	51	12	25
39	51	11	23
38	50	10	21
37	49	9	19
36	48	8	17
35	47	7	14
34	46	6	12
33	45	5	10
32	45	4	8
31	44	3	6
30	43	2	4
29	42	1	2
		0	0

Part II allows a total of 35 credits, one credit for each question, for only seven of the twelve groups in this part.