AN ACTION RESEARCH PROJECT DESIGNED TO DETERMINE IF THE BIOLOGY PROGRAM IN TOPEKA, KANSAS HIGH SCHOOL IS DEVELOPING CRITICAL THINKING BY THE TRACK I BIOLOGY STUDENTS

by

CLOVIS LEROY KNECHT

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Approved by:

J. Harvey Littrell

Major Professor

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INTRODUCTION

For a number of years, the students entering the biology classes of the Topeka High School, Topeka, Kansas, from the various junior high schools of the city have been homogeneously grouped into Track I, Track II, and Track III programs. The basis of this procedure has been followed with the assumption that the Track I students were college bound and should be subjected to an enriched program of biological study. The design of this enriched program is assumed to challenge the student to his capacity and to develop critical thinking ability.

Surveys on the percentage of college dropouts, the number of failures during the college freshman year and the small number of Topeka High School students that elected to specialize in some field of biological science as a career were facts that suggested the following problem.

STATEMENT OF THE PROBLEM

It was the purpose of this action research project (1) to determine if the Track I biology program in the Topeka High School was meeting the desired objectives; and (2) to determine if the students in Track I biology classes differ in critical thinking ability from the Track II students as measured by the _Watson-Glaser Critical Thinking Appraisal Test_[1] and the _Nelson Biology Test_.[2] An attempt was made in this study to accept or reject the following null hypotheses:

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[1]Goodwin Watson and Edward Glaser, _Watson-Glaser Critical Thinking Appraisal, Form Am_. pp. 1-8.

[2]Clarence H. Nelson, _Nelson Biology Test_, Form Am, pp. 1-8.

a. There is no significant difference between the general intelligence of the Track I biology students and the Track II biology students in Topeka High School.

b. There is no significant difference in the knowledge of biological facts and principles of the Track I biology students and the Track II students in Topeka High School.

c. There is no significant difference in the critical thinking ability of the Track I biology students and the Track II biology students in the Topeka High School.

(3) To determine the correlation between the _Watson-Glaser Critical Thinking Appraisal_ and the _Nelson Biology Test_ scores for both the Track I and the Track II groups.

DEFINITION OF TERMS USED

Action research. "Action research is a systematic examination conducted by individuals or groups studying their own practices in search of sound answers to unresolved problems in their work, and aimed at improving their own performance on their jobs."[1]

Scholarship Index of I. A grade average of B-A, as determined by the respective teachers of English, social studies, mathematics, and science, and a reading grade level of 11-12 as determined by the _California Achievement Test_ in comprehension and vocabulary is named the Scholarship Index of I.

[1]Jane Franseth, "Improving the Curriculum and Teaching Through Action Research," _Education Digest_, 25:41. April, 1960.

Scholarship Index of II. A grade average of C-B as determined by the respective teachers of English, social studies, mathematics, and science, and a reading level of 10-11 as determined by the *California Achievement Test* in comprehension and vocabulary is named Scholarship Index of II.

Track I Biology Group in Topeka High School. A group of biology students in Topeka High School who have an I. Q. of 110 or higher, as measured by the *Otis Quick Scoring Mental Ability Test* and a scholarship index of I as determined at the end of the ninth grade are considered as the Track I Biology Group.

Track II Biology Group in Topeka High School. A group of biology students in the Topeka High School who have an I. Q. of 90 - 110 as measured by the *Otis Quick Scoring Mental Ability Test* and a scholarship index of II as determined at the end of the ninth grade are considered as the Track II Biology Group.

REVIEW OF THE LITERATURE

Critical thinking in education is not a new concept. John Dewey outlined his *Method of Science* in a series of steps which included:

1. Isolate the problem.
2. Set up a hypothesis.
3. Test the hypothesis.
4. Draw conclusions on the basis of the data.

Since John Dewey advocated the use of this method of solving problems, the concept has been called the scientific method and is considered to be the most intellectual of the various forms of problem solving. Aylesworth states that the lowest form is called the method of tenacity. This method involves the solving of problems in a certain manner just because similar problems have always been solved in this manner. The process is similar to a conditioned response. The second highest form of problem solving is the method of authority. Problems are solved by this method because someone of consequence or status has dictated that a certain course of action be taken. This is necessary in the classroom for some types of study which involve the lives of scientists and for certain factors that are in remote places. The method of intuition involves a great deal of previous experience in selecting answers to questions. In the classroom, it is hoped that social values can be taught by this method. "The method of science is the only one of the four methods that can possibly admit to an error."[1]

The Wellingtons include in their Process of Critical Thinking, Dewey's steps but word them to include the following:

1. Anxiety - Become Aware of Anxiety.
   I feel this difficulty and perceive how it relates to what I already know.

2. Definition - Decide Which Problem to Pursue and How.
   Is this my problem? Shall I solve it alone or with others? What do I need to help me learn?

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[1]Thomas G. Aylesworth, "Four Kinds of Thinking in the Biology Classroom," The American Biology Teacher, 24:598, December, 1962.

3. Research - Carry out Research - Experimentation. I read, listen, manipulate equipment and symbols, travel and talk.

4. Hypothesis - Hypothesis in Light of New Evidence. I discuss or write about findings.

5. Appraisal - Appraise Findings in Light of Future Needs. I consider where my hypothesis fits past and future learning.

6. Judgment - Make a Personal Judgment with Commitment to Action. I ought to do this and I will do it.[1]

P. W. Bridgman, the eminent Harvard University physicist is credited with a definition of the scientific method which is novel. Bridgman says, "The Scientific Method is doing one's damdest with one's brain, no holds barred."[2] Russell is more erudite in his definition. "Critical thinking is a process of evaluation or categorization in terms of some previously accepted standards."[3] The Wellingtons think of critical thinking as "reasoning which results in a value judgment."[4]

Regardless of which definition is accepted, no authority in education minimizes the scientific method with its accompanying critical thinking. The scientific method is the only satisfactory method that is involved in reaching important decisions that are a part of everyone's life. Students must be taught the method of science because people in advertising

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[1]C. Burleigh Wellington and Jean Wellington, Teaching for Critical Thinking, p. 31.

[2]Clement L. Henshaw, "The Problem Approach in Physical Science," Science Education, 40:106, March, 1956.

[3]David H. Russell, Encyclopedia of Educational Research, 3rd Edition, p. 651.

[4]Wellington, op. cit., p. 21.

business, in politics, and other fields would have students arrive at decisions and conclusions on established habits, voice of authority or appeals to emotion.[1] Russell believes that in a world of conversation, admonition, newspapers, books, and television programs, the child needs to develop the ability to evaluate ideas, and to be critical in scientific, social, and personal matters. This seems to involve attitude plus knowledge of facts plus some thinking skills. It seems important that the school programs give help in developing critical thinking abilities.[2] Brubacher says that educational philosophers commonly endorse the problem method. "Indeed, so important is training in problem solving that many advocate the problem method where answers are known in advance."[3] The Wellingtons in their definition of critical thinking say that "reasoning is universally accepted as the most important form of thinking."[4] Dressel contends that "critical thinking is evidently the desired integrating principle or goal of education."[5] These statements point up the importance of critical thinking and the scientific method in the general field of education. Smith shows the importance of thinking critically in the science field. In his research on critical thinking and the science intangibles, he assumes that thinking critically ".... is a fundamental quality necessary to study science."[6]

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[1]Aylesworth, op. cit., p. 598.

[2]Russell, op. cit., p. 651.

[3]John S. Brubacher, Modern Philosophies of Education, p. 329.

[4]Wellington, op. cit., p. 13.

[5]Paul L. Dressel, "Critical Thinking," National Education Association Journal, 141:418, October, 1955.

[6]Paul M. Smith, Jr., "Critical Thinking and the Science Intangibles," Science Education, 47:405, October, 1963.

A number of investigations in subjects other than biology would support the hypothesis that critical thinking can be taught through suitable classroom procedures. There is little published about investigations at the high school level. Cohen, in discussing the significance of research in science education cites Fonsworth who found that the involvement of students in thinking produced significant gains for the students. Fonsworth showed that students who had been taught to solve chemistry problems using the reflective-thinking approach made significant gains over students taught by approaches which emphasized knowledge of facts and principles.[1] Smith in his research involving the science intangibles concluded that critical thinking ability and science understandings tended to reflect each other with respect to the behavior of boys but appeared to be of little or no consequence with that of the girls.[2] Kastrinos, in his research with the two methods of teaching high school students in advanced biology tested one class taught by the conventional textbook-recitation method. Lectures followed the text closely and emphasized factual material. Laboratory exercises were textbook-centered with emphasis on drawing and labeling parts. Home work assignments were largely of a nature that required short answers. The parallel class was taught with emphasis on major concepts and principles. Homework involved problem sheets in areas of problem recognition,

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[1]David Cohen, "The Significance of Recent Research in Secondary - School Science Education," Science Education, 48:161, March, 1964.

[2]Smith, op. cit., p. 407.

critical evaluation of data, organization of information, and awareness of the scientific method. Laboratory exercises were of the problem type in which the student had to make observations and to draw conclusions. Kastrinos found that the principles-critical thinking method was as effective as the text-recitation method in teaching factual information and was superior to the text-recitation method in developing critical thinking ability.[1] Ellsworth makes the statement that there is little evidence available to indicate the extent to which problem solving objectives are provided in day-to-day classroom activities. He concludes that it is important for the teacher to recognize that the skills of critical thinking are developed by recurrent practice and that the skills involved in the process must be taught thoroughly and then practiced until achieved. The achievement is accomplished if the teacher provides classroom situations day by day which call for their repetitive use.[2]

PROCEDURES FOLLOWED

The biology students involved in this study were sophomores and juniors in the Track I and Track II biology classes in Topeka High School. Fifty students were in the Track I group and it was assumed that these fifty students represented a random sample from the total normal

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[1] William Kastrinos, "The Relationship of Two Methods of Teaching to the Development of Critical Thinking by High School Students in Advanced Biology." Science Education, 48:195, March, 1964.

[2] Obourn S. Ellsworth, "An Analysis and Check-list on the Problem Solving Objective," Science Education, 40:388-392, December, 1956.

population of Track I students. Each of the Track I students had an I. Q. of 110 or above as measured by the Otis Quick Scoring Mental Ability Test combined with a Scholarship Index of I.

The forty-three students that were in the Track II group were assumed to represent a random sample of the normal population of Track II students. Each of the Track II students had an I. Q. of 90 to 110 as measured by the Otis Quick Scoring Mental Ability Test combined with a Scholarship Index of II. Both the Track I and the Track II groups of students had been taught by the same teacher during the school year. During the final week of the spring term, 1964, Form Am of the Nelson Biology Test was given to each student in both the Track I and Track II groups. This biology test is a general achievement test designed for high school students who have completed one year of biology.

In order to sample behavior of the subjects' ability to think critically, the Am Form of the Watson-Glaser Critical Thinking Appraisal (W.G.C.T.A.) was administered to each student in both the Track I and Track II groups. This testing device attempts to measure such qualities of thinking as inference, assumption, deduction, interpretation, and evaluation of arguments. The test was administered the day following the Nelson Biology Test during the final week of the spring term, 1964.

The Otis Quick Scoring Mental Ability Test scores were secured from each student's junior high school record. The records were obtained from the Topeka High School Guidance Department.

ANALYSIS OF THE DATA

The data for each of the tests--intelligence, biology achievement, and critical thinking--were organized into frequency distributions and the means and standard deviations were calculated. The means and standard deviations for each of these tests for both the Track I and Track II groups are given in Table I. The Track I pupils had a higher mean in the three factors analyzed: intelligence quotient, knowledge of biological facts and critical thinking. The standard deviation, a measure of variance, shows that the amount of variance within the Track I and the Track II groups was similar except for the Watson-Glaser Critical Thinking Appraisal Test where Track II pupils varied more than the Track I pupils. The standard deviation of 22.25 for the Track II group was much greater than the 11.84 value for the Track I pupils taking the same test.

TABLE I

THE MEANS AND STANDARD DEVIATIONS FOR THE THREE TESTS GIVEN TO TRACK I AND TRACK II STUDENTS

	Number of pupils	Mean	Standard deviation
I. Q.			
Track I	50	114.98	9.23
Track II	43	97.97	11.44
Nelson Biology			
Track I	50	125.08	11.87
Track II	43	104.83	12.03
W.G.C.T.A.			
Track I	50	83.42	11.84
Track II	43	55.65	22.25

Two different statistical procedures were used to determine the reliability of the difference between the two means for each of the factors tested as shown in Table I. The data used for determining the reliability between the two uncorrelated means for each of the factors tested is given in Table II. Using the difference of 17.01 between the Track I I. Q. mean and the Track II mean and the standard error of difference of the means of 2.02, the critical ratio value of 5.02 was determined. From a table of chances based on the critical ratio, it was found there were 99.9 chances out of one hundred that the true difference between the means was greater than zero. Therefore, the null hypothesis concerning differences in I. Q. was rejected. On the same basis, the critical ratio value of 8.16 would indicate a significant difference between the mean in the two groups for the Nelson Biology Test and the null hypothesis concerning the knowledge of biological facts and principles would be rejected. The critical ratio value of 4.70 would reject the null hypothesis for critical thinking. This critical ratio value indicates that the two groups, Track I and Track II are significantly different in intelligence, knowledge of biological facts, and critical thinking ability. The critical ratios show that there was a greater variation between the means for biology achievement than for critical thinking. If the teaching methods had affected the critical thinking of the Track I biology students, then a higher critical ratio should have been obtained.

The second statistical procedure used to determine the reliability of the difference between the two means for each of the factors tested

TABLE II

THE STATISTICS USED TO DETERMINE THE RELIABILITY OF THE DIFFERENCE BETWEEN THE TWO MEANS OF THE THREE TESTS GIVEN TO TRACK I AND TRACK II STUDENTS

	Difference between means	Standard error of the difference between means	Critical ratio D/σ_d
I. Q. Track I Track II	17.01	2.02	5.02
Nelson Biology Track I Track II	20.25	2.48	8.16
W.G.C.T.A. Track I Track II	17.77	3.78	4.70

was the t-ratio. The t-ratio values and the corresponding t-ratio probability are given in Table III. For each of the factors tested, intelligence, biological facts, and critical thinking, the values indicate a significant difference between the two groups and the null hypothesis was rejected at a level much less than the 0.1 percent level of confidence for each of the three factors tested.

TABLE III

t-RATIO AND LEVEL OF SIGNIFICANT VALUES
FOR THE TESTS ADMINISTERED

	t-Ratio	Level of significance (p)
I. Q.		
Track I	4.67	$p < .001$
Track II		
Nelson Biology		
Track I	8.16	$p < .001$
Track II		
W.G.C.T.A.		
Track I	4.70	$p < .001$
Track II		

A third purpose of the study was to determine whether or not there was a correlation between the Watson-Glaser Critical Thinking Appraisal and the Nelson Biology Test scores in both Track I and Track II groups. To do this a rank-order coefficient of correlation was determined. No attempt was made to determine the correlation between critical thinking and intelligence because the Watson-Glaser Critical Thinking Test Manual[1] shows a correlation of 0.697 between the Terman-McNemar I. Q. Test and the Watson-Glaser Critical Thinking Appraisal and a correlation of 0.48 between the Watson-Glaser Critical Thinking Appraisal and the Otis Gamma. The writer therefore assumed a comparable low correlation would also be

[1]Goodwin Watson and Edward Maynard Glaser, Watson-Glaser Critical Thinking Appraisal Manual, copyright, 1952, p. 10.

obtained between the Otis Quick Scoring Mental Ability Test and the Watson-Glaser Critical Thinking Appraisal. Table IV shows the rank-order coefficient of correlation values between the Nelson Biology Test and the Watson-Glaser Critical Thinking Appraisal. The r value of 0.446 for the Track I students would indicate a low correlation for that group and an r value of 0.497 for the Track II students would indicate a low correlation for this group between achievement in biology and critical thinking.

TABLE IV

RANK-ORDER COEFFICIENT OF CORRELATION

	r-Value
Track I	
Nelson Biology and W.G.C.T.A.	0.446
Track II	
Nelson Biology and W.G.C.T.A.	0.497

SUMMARY AND RECOMMENDATIONS

The writer is aware of the limitations of this study. If it had been possible to give both Track I and Track II biology students pre-tests at the beginning of the school year and post-tests at the end of the school year, statistical procedures could have been used to determine growth in achievement and critical thinking.

From tha statistics used in this study it was found (1) that for Track I and Track II biology students the difference between the means in intelligence, biology achievement, and critical thinking was significant; (2) there was a moderate correlation between biology achievement and critical thinking; (3) from the literature concerning the _Watson-Glaser Critical Thinking Appraisal_ it was assumed that there is a low correlation between critical thinking and intelligence; and (4) a greater variation existed between groups in biology achievement than in critical thinking.

It could not be proved that any change in the critical thinking ability of the students making up the two groups could be attributed to any known factor.

It would appear that the teaching methods used in Track I biology classas under study had very little effect in the development of critical thinking procedures by the students making up Track I in the Topeka High School. This statement is based on the facts given above, that is, a true difference existed between the classes in all of the factors tested, and yet there was little correlation between the factors. Also there was a greater variation between groups in biology achievement than in critical thinking.

It would seem plausible that if the methods used to teach biology to the Track I students did affect to a greater extent their critical thinking, then there would have been a higher correlation between their achievement in biology and their critical thinking scores. Actually there was little difference in the coefficients of correlation for Track I and Track II students between biology achievement and critical thinking. Also, if the teaching methods had great effect on their biology achievement, it would seem that there would have been greater variation between the groups on the critical thinking appraisal.

A reappraisal of the objectives of Track I biology in Topeka High School would be in order at this time, and if the concept of critical thinking is to be a teaching objective, the democratic group processes should be initiated to change the teaching practices in Track I biology in order that the students in Track I would have the opportunity to practice the skills that would lead to more critical thinking ability.

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APPENDIX

TABLE V

TRACK I, I. Q. SCORES

Pupil	I. Q. Score	Pupil	I. Q. Score
E	138	C	114
A	137	M	113
G	136	DD	113
D	134	H	112
V	132	B	112
Q	128	GG	112
S	127	UU	112
EE	126	OO	112
I	126	VV	112
LL	123	AA	110
PP	123	T	109
J	123	SS	108
R	123	JJ	108
KK	122	X	107
HH	122	BB	107
L	122	XX	105
Z	121	NN	105
W	120	WW	103
F	120	QQ	103
O	120	II	101
CC	119		
N	119		
U	118		
MM	118		
FF	117		
K	116		
D	116		
Y	116		
RR	114		
TT	114		

Mean I. Q. = 114.98

TABLE VI

TRACK II, I. Q. SCORES

Pupil	I. Q. Score	Pupil	I. Q. Score
bb	123	ee	91
b	120	a	91
e	113	n	90
d	111	x	90
f	109	j	90
p	107	ll	89
z	107	hh	88
q	107	gg	88
l	105	mm	87
c	105	oo	85
s	105	cc	85
aa	103	ii	84
qq	102	pp	84
g	102		
y	102		
r	100		
v	100		
dd	99		
o	99		
t	98		
w	98		
kk	97		
m	96		
i	96		
h	96		
ff	95		
jj	95		
u	94		
nn	94		
k	93		

Mean I. Q. = 97.97

TABLE VII

STANDARD DEVIATIONS
NELSON BIOLOGY
TRACK I

Pupil	Scores (X)	Deviations ($x = X-M$)	Deviations squared (x^2)
A	147	21.92	480.49
B	146	20.92	437.65
C	143	17.92	321.13
D	143	17.92	321.13
E	141	15.92	253.45
F	141	15.92	253.45
G	139	13.92	193.77
H	138	12.92	166.93
I	138	12.92	166.93
J	137	11.92	142.09
K	135	9.92	98.41
L	135	9.92	98.41
M	133	7.92	62.73
N	133	7.92	62.73
O	133	7.92	62.73
P	133	7.92	62.73
Q	129	3.92	15.37
R	129	3.92	15.37
S	129	3.92	15.37
T	127	1.92	3.69
U	127	1.92	3.69
V	127	1.92	3.69
W	127	1.92	3.69
X	125	0.08	0.01
Y	125	0.08	0.01
Z	125	0.08	0.01
AA	124	-1.08	1.17
BB	124	-1.08	1.17
CC	124	-1.08	1.17
DD	124	-1.08	1.17

TABLE VII (Continued)

Pupil	Scores (X)	Deviations ($x = X-M$)	Deviations squared (x^2)
EE	124	-1.08	1.17
FF	123	-2.08	4.33
GG	122	-3.08	9.49
HH	122	-3.08	9.49
II	120	-5.08	25.81
JJ	119	-6.08	36.97
KK	118	-7.08	50.13
LL	118	-7.08	50.13
MM	116	-9.08	82.45
NN	116	-9.08	82.45
OO	115	-10.08	101.61
PP	115	-11.08	101.61
QQ	113	-12.08	145.93
RR	112	-13.08	171.09
SS	111	-14.08	198.25
TT	110	-15.08	227.41
UU	104	-21.08	444.37
VV	101	-24.08	579.85
WW	98	-27.08	733.33
XX	98	-27.08	733.33
		Total	7039.54

Mean = 125.08

TABLE VIII

STANDARD DEVIATIONS
NELSON BIOLOGY
TRACK II

Pupil	Scores (X)	Deviations ($x = X-M$)	Deviations squared (x^2)
a	131	26.17	684.87
b	125	20.17	406.83
c	124	19.17	367.49
d	123	18.17	330.15
e	122	17.17	294.81
f	121	16.17	261.47
g	116	11.17	124.77
h	115	10.17	103.43
i	114	9.17	84.09
j	114	9.17	84.09
k	113	8.17	66.75
l	113	8.17	66.75
m	112	7.17	51.41
n	111	6.17	38.07
o	110	5.17	26.73
p	109	4.17	17.39
q	109	4.17	17.39
r	109	4.17	17.39
s	109	4.17	17.39
t	106	1.17	1.37
u	105	0.17	0.03
v	104	-0.83	0.69
w	103	-1.83	3.35
x	101	-3.83	14.67
y	101	-3.83	14.67
z	100	-4.83	24.33
aa	100	-4.83	24.33
bb	100	-4.83	24.33
cc	100	-4.83	24.33
dd	98	-6.83	46.65

TABLE VIII (Continued)

Pupil	Scores (X)	Deviations (x = X-M)	Deviations squared (x^2)
ee	98	-6.83	46.65
ff	98	-6.83	46.65
gg	98	-6.83	46.65
hh	96	-8.83	77.97
ii	95	-9.83	96.63
jj	95	-9.83	96.63
kk	93	-11.83	139.95
ll	93	-11.83	139.95
mm	92	-12.83	164.61
nn	90	-14.83	219.93
oo	87	-17.83	317.91
pp	80	-24.83	616.53
qq	75	-29.83	889.83
		Total	6139.91

Mean = 104.83

TABLE IX

STANDARD DEVIATIONS
W.G.C.T.A.
TRACK I

Pupil	Scores (X)	Deviations ($x = X-M$)	Deviations squared (x^2)
K	99	15.58	242.74
I	98	14.58	212.58
FF	98	14.58	212.58
B	98	14.58	212.58
P	98	14.58	212.58
A	97	13.58	184.41
J	95	11.58	134.10
D	95	11.58	134.10
O	93	9.58	91.78
LL	92	8.58	73.62
V	91	7.58	54.46
C	91	7.58	54.46
QQ	90	6.58	43.30
M	90	6.58	43.30
KK	90	6.58	43.30
F	89	5.58	31.14
L	89	5.58	31.14
RR	89	5.58	31.14
NN	89	5.58	31.14
DD	88	4.58	20.98
CC	88	4.58	20.98
R	88	4.58	20.98
HH	88	4.58	20.98
U	88	4.58	20.98
II	86	2.58	6.66
PP	86	2.58	6.66
H	85	1.58	2.50
AA	85	1.58	2.50
S	85	1.58	2.50
G	85	1.58	2.50

TABLE IX (Continued)

Pupil	Scores (X)	Deviations (x = X-M)		Deviations squared (x^2)
X	85	1.58		2.50
Y	83	-0.42		0.18
UU	83	-0.42		0.18
WW	83	-0.42		0.18
TT	83	-0.42		0.18
GG	83	-0.42		0.18
T	81	-2.42		5.86
JJ	79	-4.42		19.54
MM	79	-4.42		19.54
N	77	-6.42		41.22
BB	74	-9.42		88.74
OO	72	-11.42		130.42
W	72	-11.42		130.42
Q	69	-14.42		207.94
Z	63	-20.42		416.98
E	60	-23.42		548.50
SS	60	-23.42		548.50
XX	60	-23.42		548.50
VV	53	-30.42		925.38
EE	49	-34.42		1184.74
			Total	7022.36

Mean = 83.42

TABLE X

STANDARD DEVIATIONS
W.G.C.T.A.
TRACK II

Pupil	Scores (X)	Deviations ($x = X-M$)	Deviations squared (x^2)
l	97	41.35	1709.82
c	89	33.35	1105.56
d	89	33.35	1105.56
e	85	29.35	861.42
r	85	29.35	861.42
t	81	25.35	642.62
bb	81	25.35	642.62
n	77	21.35	455.82
k	77	21.35	455.82
o	74	18.35	336.72
ll	72	16.35	267.32
w	72	16.35	267.32
j	69	13.35	178.22
a	66	10.35	107.12
ii	66	10.35	107.12
f	66	10.35	107.12
q	63	7.35	54.02
x	63	7.35	54.02
gg	63	7.35	54.02
b	60	4.35	18.92
ee	60	4.35	18.92
z	60	4.35	18.92
qq	60	4.35	18.92
dd	56	0.35	0.12
ff	56	0.35	0.12
s	56	0.35	0.12
p	53	-2.65	7.02
cc	53	-2.65	7.02
kk	49	-6.65	44.22
u	42	-13.65	186.32

TABLE X (Continued)

Pupil	Scores (X)	Deviations ($x = X-M$)	Deviations squared (x^2)
h	42	-13.65	186.32
jj	42	-13.65	186.32
i	39	-16.65	277.22
v	39	-16.65	277.22
m	35	-17.65	311.52
oo	35	-17.65	311.52
aa	32	-23.65	559.32
pp	22	-33.65	1132.32
y	16	-39.65	1572.12
g	16	-39.65	1572.12
hh	16	-39.65	1572.12
nn	13	-42.65	1819.02
mm	6	-49.65	2465.12
		Total	21290.44

Mean = 55.65

TABLE XI

RANKING OF TRACK I
NELSON BIOLOGY
AND
W.G.C.T.A.

Pupil	Score	Order	W.G.C.T.A.	Difference between ranks (D)	D^2
A	147	1	6	5.0	25.00
B	146	2	2.5	0.5	0.25
C	143	3.5	11.5	8.0	64.00
D	143	3.5	7.5	4.0	16.00
E	141	5.5	46.5	41.0	1681.00
F	141	5.5	16.5	11.0	121.00
G	139	7.0	27.5	20.5	420.25
H	138	8.5	27.5	19.0	361.00
I	138	8.5	2.5	6.0	36.00
J	137	10.0	7.5	2.5	6.10
K	135	11.0	1.0	10.0	100.00
L	134	12.0	16.5	4.5	20.25
M	133	13.5	13.5	0.0	00.00
N	133	13.5	40.0	26.5	702.25
O	133	13.5	9.0	4.5	20.25
P	133	13.5	2.5	11.0	121.00
Q	129	17.5	44.0	26.5	702.25
R	129	17.5	20.5	3.0	9.00
S	129	17.5	27.5	10.0	100.00
T	127	20.5	37.0	16.5	272.25
U	127	20.5	20.5	0.0	00.00
V	127	20.5	11.5	9.0	81.00
W	127	20.5	42.5	12.0	144.00
X	125	24.5	27.5	3.0	9.00
Y	125	24.5	32.5	8.0	64.00
Z	125	24.5	45.0	20.5	420.25
AA	124	27.5	50.0	22.5	506.25
BB	124	27.5	41.0	13.5	182.25
CC	124	27.5	20.5	7.0	49.00
DD	124	27.5	20.5	7.0	49.00

TABLE XI (Continued)

Pupil	Score	Order	W.G.C.T.A.	Difference between ranks (D)	D^2
EE	124	27.5	27.5	0.0	00.00
FF	123	32.0	2.5	29.5	870.25
GG	122	33.5	32.5	1.0	1.00
HH	122	33.5	20.5	13.0	169.00
II	120	35.0	25.5	9.5	90.25
JJ	119	36.0	38.5	2.5	6.25
KK	118	37.5	13.5	24.0	576.00
LL	118	37.5	10.0	27.5	756.25
MM	116	39.5	39.5	38.5	1.00
NN	116	39.5	16.5	23.0	529.00
OO	115	41.0	42.5	1.5	2.25
PP	114	42.0	25.5	16.5	272.25
QQ	113	43.0	13.5	28.5	812.25
RR	112	44.0	16.5	27.5	756.25
SS	111	45.0	46.5	1.5	2.25
TT	110	46.0	32.5	13.5	182.25
UU	104	47.0	32.5	14.5	210.25
VV	101	48.0	49.0	1.0	1.00
WW	98	49.5	32.5	17.0	289.00
XX	98	49.5	46.5	3.0	9.00
				ΣD^2 =	11,818.35

TABLE XII

RANKING OF TRACK II
NELSON BIOLOGY
AND
W.G.C.T.A.

Pupil	Score	Order	W.G.C.T.A.	Difference between ranks (D)	D^2
a	131	1.0	14.5	13.5	182.25
b	125	2.0	20.5	18.5	342.25
c	124	3.0	2.5	0.5	0.25
d	123	4.0	2.5	1.5	2.25
e	122	5.0	4.5	1.5	2.25
f	121	6.0	14.5	8.5	72.25
g	116	7.0	39.5	32.5	1056.25
h	115	8.0	30.5	22.5	506.25
i	114	9.5	33.5	24.0	576.00
j	114	9.5	13.0	3.5	12.25
k	113	11.5	8.5	3.0	9.00
l	113	11.5	1.0	10.5	110.25
m	112	13.0	35.5	22.5	506.25
n	111	14.0	8.5	5.5	24.25
o	110	15.0	10.0	5.0	25.00
p	109	16.5	27.5	11.0	121.00
q	109	16.5	17.5	1.0	1.00
r	109	16.5	4.5	12.0	144.00
s	109	16.5	24.5	8.0	64.00
t	106	20.0	6.5	13.5	182.25
u	105	21.0	30.5	9.5	90.25
v	104	22.0	33.5	11.5	132.25
w	103	23.0	11.5	11.5	132.25
x	101	24.5	17.5	7.0	49.00
y	101	24.5	39,5	15.0	225.00
z	100	26.5	20.5	6.0	36.00
aa	100	26.5	37.0	10.5	110.25
bb	100	26.5	6.5	20.0	400.00
cc	100	26.5	27.5	1.0	1.00
dd	98	30.5	24.5	6.0	36.00

TABLE XII (Continued)

Pupil	Score	Order	W.G.C.T.A.	Difference between ranks (D)	D^2
ee	98	30.5	20.5	10.0	100.00
ff	98	30.5	24.5	6.0	36.00
gg	98	30.5	17.5	13.0	169.00
hh	96	34.0	20.5	13.5	182.25
ii	95	35.5	14.5	21.0	441.00
jj	95	35.5	30.5	5.0	25.00
kk	93	37.5	29.0	8.5	72.25
ll	93	37.5	11.5	26.0	676.00
mm	92	39.0	43.0	4.0	16.00
nn	90	40.0	42.0	2.0	4.00
oo	87	41.0	35.5	5.5	24.25
pp	80	42.0	38.0	4.0	16.00
qq	75	43.0	39.5	3.5	12.25
				$\Sigma D^2 =$	6925.25

AN ACTION RESEARCH PROJECT DESIGNED TO DETERMINE IF THE BIOLOGY PROGRAM IN TOPEKA, KANSAS HIGH SCHOOL IS DEVELOPING CRITICAL THINKING BY THE TRACK I BIOLOGY STUDENTS

by

CLOVIS LEROY KNECHT

B. S., Kansas State University, 1933

AN ABSTRACT OF A MASTER'S REPORT

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KANSAS STATE UNIVERSITY
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1964

The purpose of this action research project was to determine if there was evidence that the biology program in Topeka, Kansas High School was developing critical thinking in the Track I students.

In Topeka High, the biology classes are divided into Tracks. The Track I students are those students with an I. Q. of 110 or above and with a Scholarship Index of I. Most of these students are potential college students.

Track II students are those students with an I. Q. of 90 - 110 and with a Scholarship Index of II. In Topeka High School, they are referred to as the average students.

Null hypotheses were set up for the three factors tested; intelligence, biological factual information, and critical thinking ability.

A statistical comparison of the I. Q. means between the two groups was made to determine if there was actually a difference in mean intelligence between the biology students in the Track I and Track II groups.

A statistical comparison of the means for biological factual information between the Track I and Track II groups was made as well as a statistical comparison between Track I and Track II for critical thinking ability.

A rank-order correlation was made between the Watson-Glaser Critical Thinking Appraisal and the Nelson Biology Test scores for both Track I and Track II groups.

From the statistical analysis, it was found that there was a significant difference between the Track I and Track II students in intelligence, biology achievement, and critical thinking ability. It was assumed that for the Topeka High School Biology students, there was a moderately low correlation between critical thinking and intelligence. A greater variation existed between the groups in biology achievement than for critical thinking. Any change in critical thinking could not be attributed to any one factor, but it would appear that the biology teaching methods had very little effect in the development of critical thinking ability.

A reappraisal of the objectives of Track I biology in Topeka High School would determine if the development of critical thinking ability is a school objective and if it is, processes should be initiated to change the teaching procedures and practices in Track I to make the development of these skills possible.