THE RELATIONSHIP BETWEEN COGNITIVE PERFORMANCE AND CRITICAL THINKING ABILITIES AMONG SELECTED AGRICULTURAL EDUCATION STUDENTS

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Several researchers have measured and analyzed cognitive performance (Newcomb & Trefz, 1987; Cano, 1988; Pickford, 1988) and analyzed critical thinking abilities of students (Kahler, Millers, & Rollins, 1988; Arter & Salmon, 1987; Ennis, 1985). Past research has indicated that most students show little evidence of using critical thinking abilities when solving problems; in fact, most students continue to operate in a concrete operational manner (Day, 1981).

Furthermore, researchers have identified cognitive deficiencies that characterize poor problem solvers, with a passive approach to learning as an underlying causal factor (Chance, 1981; Lochhead, 1981). Fuerestein (1980) and Jensen (1969, 1973) believed that intellectual capacities were not entirely determined by heredity and that cognitive performance could be positively influenced, perhaps through the problem solving approach to teaching.

The problem solving approach has been one of the cornerstones of agricultural education instruction. Although agricultural education instructors are familiar with and may use the problem solving techniques, are agriculture students actually capable of critically thinking through problem situations? Do agriculture students think at higher levels of cognition to solve problems? Furthermore, does a relationship exist between cognitive performance and critical thinking abilities of agricultural education students?

Purpose and Objectives

The purpose of this study was to determine the extent to which students in agricultural education programs were performing at the various levels of cognition utilizing Bloom's Taxonomy (Bloom, Englehart, Furst, Hill, & Krathwohl, 1956). In addition, this study sought to determine the extent to which agricultural education students think critically. Furthermore, this study sought to determine the relationship between level of cognitive performance and critical thinking ability.

For the purpose of this study, level of cognition was defined as the type of cognitive process needed to answer a particular question. Critical thinking was defined as a set of thinking skills needed to answer a particular question.

The following research questions were investigated:

1. What was the cognitive level of performance of agricultural education students as measured by the Developing Cognitive Abilities Test (DCAT)?
2. What was the critical thinking ability of agricultural education students as measured by the Watson-Glaser Critical Thinking Appraisal (W-GCTA)?
3. What was the relationship between the DCAT and the W-GCTA scores of the agricultural education students?

Procedures

Population and Sample: The population for this descriptive-correlational study was the students enrolled in secondary agricultural education classes in Ohio during 1988-89. Ten schools were purposefully selected for this study by teacher educators and state supervisors. The criteria used for selection were: student SAE, FFA program, course of study, administrative commitment, and overall facilities. All students (n = 385) enrolled in agricultural education classes at the selected secondary schools were included in the sample. The results of this study are generalizable only to the sample.

Instrumentation: The DCAT and the W-GCTA were administered to the agricultural education students enrolled in agricultural education programs at the selected secondary schools. The DCAT is divided into subtests which are based on the levels of Bloom's Taxonomy (Bloom et al., 1956), and

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are hierarchical in nature. The Basic Abilities subtest includes items classified as knowledge/comprehension, the Application Abilities subtest includes items classified as application, and the Critical Thinking Abilities subtest is comprised of items at the analysis/synthesis levels.

The W-GCTA, based on Dressel and Mayhew's (1954) skills of critical thinking, is comprised of five subtests which are not hierarchical in nature. The five subtests are Inference, Recognition of Assumptions, Deduction, Interpretation, and Evaluation of Arguments.

Validity and reliability have been established by the developers of both standardized tests used in this study. Developers of the DCAT have determined that the subtests have good reliability: Basic Abilities, .81; Application Abilities, .76; Critical Thinking Abilities, .75; and Overall, .81. Developers of the W-GCTA have determined that it has good reliability for grades 9-12: ninth grade, .69; tenth grade, .73; eleventh grade, .76; and twelfth grade, .76. For the current study, a post-hoc analysis yielded similar reliability coefficients for the DCAT subtests: Basic Abilities, .80; Application Abilities, .76; Critical Thinking Abilities, .72; and Overall, .90. For the W-GCTA, post-hoc reliability analysis coefficients were: ninth grade, .68; tenth grade, .73; eleventh grade, .77; and twelfth grade, .75.

Data Collection: The DCAT and the W-GCTA were mailed to each agricultural education instructor at each selected secondary school for administration. Each respective test was accompanied by specific instructions for test administration. In addition, the teachers were asked to complete a test administration form for each test to ensure compliance with the directions. All tests were administered on two consecutive days during the first week of May, 1989. After administering the tests, the teachers returned the tests and administration forms to the researchers.

Analysis of Data

Descriptive statistics were used to determine and describe student cognitive level of performance and critical thinking abilities. Canonical correlation was used to describe the relationship between the DCAT scores and the W-GCTA scores. All tests were scored manually by one of the researchers following instructions from the developers of each respective test.

Results

DCAT Subtest Scores by Grade Level: All students scored highest on the Basic Abilities subtest, lower on the Application Abilities, and lowest on the Critical Thinking Abilities (See Table 1). Tenth grade students scored higher than eleventh grade students on Basic Abilities, Application Abilities, and overall (DCAT total). Ninth grade students scored consistently lower than all other students on all subtests and the DCAT total. In addition, a linear trend was found on the Critical Thinking Abilities subtest as students advanced by grade level.

Table 1
Means of Scores for Cognitive Subtests of the Developing Cognitive Abilities Test by Grade Level

Grade Level	N	Level of Cognitive Subtest			
		Basic	Application	Critical Thinking	DCAT Total
9	96	17.17	14.88	11.94	43.81
10	114	18.23	16.35	12.91	47.45
11	88	17.32	16.31	13.09	46.81
12	86	18.14	17.01	13.58	48.71
Total	384	17.73	16.12	12.86	46.67

Note. Maximum score = 27 per subtest; Total maximum score = 81.

W-GCTA Subtest Scores by Grade Level: The mean scores across grade levels for subtests of the W-GCTA are depicted on Table 2. Students at all grade levels scored lowest on the Inference

subtest with mean scores ranging from 5.69 to 6.34 based on a maximum scores of 16 (See Table 2). In addition, twelfth grade students consistently scored higher than students at the other grade levels.

Table 2
Means of Scores for Subtests of the Watson-Glaser Critical Thinking Appraisal by Grade Level

Grade Level	N	Critical Thinking Subtests					W-GCTA Total
		Infer.	Assump.	Deduct.	Interp.	Argue.	
9	96	5.71	9.02	8.95	8.89	9.14	41.73
10	114	5.69	9.44	8.68	9.33	9.22	42.27
11	88	5.75	9.61	8.75	8.77	8.75	41.66
12	86	6.34	10.07	9.14	8.60	9.65	42.35

Note. Maximum score = 16 per subtest; Total maximum score = 80.

Relationship Between the DCAT and the W-GCTA: The relationship between student scores on the DCAT and student scores on the W-GCTA was calculated utilizing the canonical correlation procedure. Table 3 (following page) presents the correlation matrix depicting the relationship between the independent (predictor) and dependent (criterion) variables. The magnitude of the correlation coefficients is described using Davis' (1971) interpretations.

The intercorrelations among the criterion variable set revealed substantial positive correlations. Among the predictor variable set, low to moderate positive intercorrelations were found. The correlations between the individual predictor and individual criterion variables resulted in low to moderate positive coefficients.

The null hypothesis tested was that all squared canonical correlations ($R^2_{c(s)}$) equaled zero. Conducting a test of significance for the canonical function was accomplished using Wilks Lambda. This test was significant at $p = .01$ (See Table 4). The null hypothesis was rejected, indicating that the first squared canonical correlation ($R^2_{c(1)}$) was statistically significant.

Table 4
Canonical Correlation Analysis

Function	Eigen Value	Canonical Correlation	Squared Canonical Correlation	F Test	p
1	.459	.561	.315	10.81	.010
2	.017	.128	.016	1.04	.404
3	.005	.073	.005	0.67	.569

Note. Wilks Lambda = .671; $F = 10.81$ (df 15,384); $p = .010$.

Standardized Canonical and Structure Coefficients: An examination of standardized canonical weights for the covariates (See Table 5) revealed that for the independent variables the betas ranged from -.450 to -.161 with inference and interpretation being relatively most important. For the dependent variables the betas ranged from -.506 to -.227 with critical thinking being relatively most important (See Table 5).

The magnitude of the structure coefficients was interpreted following guidelines established by Chuatong (1986). The interpretations were: .24 or less, Low; .25 to .64, Moderate; and .65 or greater, High. On the criterion variable set, Critical Thinking Abilities (-.919) loaded highest on Canonical Variate 1, with Basic Abilities (-.879) and Application Abilities (-.843) also found to be high (See Table 5). Of the predictor variable set, Inference (-.750) and Interpretation (-.735) loaded highest on Canonical Variate 1 (See Table 5).

Table 3
Relationship* Between the Developing Cognitive Abilities Test and the Watson-Glaser Critical Thinking Appraisal (N = 384)

	Criterion Variable Set (Percent Items Correct) Developing Cognitive Abilities Test			Predictor Variable Set (Percent Items Correct) Watson-Glaser Critical Thinking Appraisal				
	B	A	C	I	RA	D	IN	EA
Criterion Variable Set								
Basic Abilities (B)	1.000							
Application Abilities (A)	.685	1.000						
Critical Thinking Abilities (C)	.656	.686	1.000					
Predictor Variable Set								
Inference (I)	.379	.335	.387	1.000				
Recognition of Assumptions (RA)	.266	.215	.267	.271	1.000			
Deduction (D)	.219	.234	.269	.237	.136	1.000		
Interpretation (IN)	.375	.362	.362	.332	.133	.354	1.000	
Evaluation of Arguments (EA)	.255	.298	.305	.207	.177	.172	.338	1.000

Note. B = Basic; A = Application; C = Critical Thinking; I = Inference; RA = Recognition of Assumptions; D = Deduction; IN = Interpretation; EA = Evaluation of Arguments.
* Pearson's Product Moment Correlation Coefficients.

Table 5
Summary of Canonical Correlation Analysis

Variable	Canonical Variate 1 b	s	Canonical Variate 2 b	s	Canonical Variate 3 b	s
Criterion Variable Set						
Basic Abilities	-.391	-.879	1.364	.419	.375	.229
Application Abilities	-.227	-.843	-1.061	-.353	1.068	.406
Critical Thinking Abilities	-.506	-.919	-.331	-.164	-1.339	-.359
Predictor Variable Set						
Inference	-.405	-.750	.304	.255	-.337	-.247
Recognition of Assumptions	-.271	-.514	.437	.356	-.330	-.371
Deductions	-.161	-.491	-.403	-.298	-.600	-.384
Interpretations	-.409	-.735	.321	.052	.948	.591
Evaluation of Arguments	-.259	-.554	-.886	-.771	.036	.121
Redundancy		.170		.011		.003
	$R^2_{c(1)}$ = .315		$R^2_{c(2)}$ = .016		$R^2_{c(3)}$ = .005	

Note. b = Standardized Canonical Coefficient; s = Structure Coefficient

Conclusions and/or Recommendations

It was concluded in this study that a substantial positive relationship existed between student mean scores on the DCAT and student mean scores on the W-GCTA. In addition, all intercorrelations were low to substantial and positive, indicating that as scores on one test increased, a corresponding increase was found on the other test. These findings suggest the importance for agricultural educators to challenge students to develop cognitive abilities and critical thinking abilities at higher levels via the instruction they provide. Research has shown that thinking strategies are most effective when taught in conjunction with the appropriate subject matter content (Chautong, 1986; Arter and Salmon, 1987; Sternberg, 1985; Baron, 1987).

In regard to student performance on the various levels of cognition, this study found that when compared to the findings of previous studies (Newcomb and Trefz, 1987; Cano, 1988; Pickford, 1988), the students in this study were performing at levels of cognition comparable to those of other agriculture students. However, the students of agriculture tended to score at higher percentages than students of other subjects such as science (Billeh, 1974), English (Purves, 1971), and social sciences (Hunkins, 1969).

Again, the question surfaces whether the problem solving approach to teaching is the catalyst which serves to elevate the agriculture students' level of cognition. Further research needs to be conducted to determine the extent to which problem solving instruction, which has been the cornerstone of agricultural education contributes to the cognitive ability and critical thinking ability development of the students. In addition, further research is recommended to determine if the results of this study are generalizable for the population of agriculture students, and whether similar results would be found by comparing agriculture students to the general student body.

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